4. Ecological Risk Characterization

a. Summary of Risk Assumptions

Risk characterization integrates the results of the exposure and ecotoxicity data to evaluate the likelihood of adverse ecological effects. The means of integrating the results of exposure and ecotoxicity data is called the quotient method. For this method, risk quotients (RQs) are calculated by dividing exposure estimates by ecotoxicity values, both acute and chronic.

RQ = EXPOSURE/TOXICITY

RQs are then compared to OPP's levels of concern (LOCs). These LOCs are criteria used by OPP to indicate potential risk to nontarget organisms and the need to consider regulatory action. The criteria indicate that a pesticide used as directed has the potential to cause adverse effects on nontarget organisms. LOCs currently address the following risk presumption categories: (1) **acute high** - potential for acute risk is high and regulatory action may be warranted in addition to restricted use classification (2) **acute restricted use** - the potential for acute risk is high, but this may be mitigated through restricted use classification (3) **acute endangered species** - the potential for acute risk to endangered species is high and regulatory action may be warranted, and (4) **chronic risk** - the potential for chronic risk is high regulatory action may be warranted. Currently, EFED does not perform assessments for chronic risk to plants, acute or chronic risks to nontarget insects, or chronic risk from granular/bait formulations to mammalian or avian species.

The ecotoxicity test values (i.e., measurement endpoints) used in the acute and chronic risk quotients are derived from the results of required studies. Examples of ecotoxicity values derived from the results of short-term laboratory studies that assess acute effects are: (1) LC50 (fish and birds) (2) LD50 (birds and mammals (3) EC50 (aquatic plants and aquatic invertebrates) and (4) EC25 (terrestrial plants). Toxicity test effect levels derived from the results of long-term laboratory studies that assess chronic effects are NOAEL and LOAEL for birds and mammals and NOAEC and LOAEC for fish and aquatic invertebrates. The NOAEL value is used as the ecotoxicity test value in assessing chronic effects.

Risk presumptions, along with the corresponding RQs and LOCs are tabulated below.

Risk Presumptions for Terrestrial Animals

Risk Presumption	RQ	LOC
Birds and Mammals		
Acute High Risk	EEC[1]/LC50 or LD50/sqft[2] or LD50/day[3]	0.5
Acute Restricted Use	EEC/LC50 or LD50/sqft or LD50/day (or LD50 < 50 mg/kg)	0.2
Acute Endangered Species	EEC/LC50 or LD50/sqft or LD50/day	0.1
Chronic Risk	EEC/NOAEC	1

[1] abbreviation for Estimated Environmental Concentration (ppm) on avian/mammalian food items

[2] $\frac{\text{mg/ft}^2}{\text{LD50 * wt. of bird}}$ [3] $\frac{\text{mg of toxicant consumed/day}}{\text{LD50 * wt. of bird}}$

Risk Presumptions for Aquatic Animals

Risk Presumption	RQ	LOC
Acute High Risk	EEC[1]/LC50 or EC50	0.5
Acute Restricted Use	EEC/LC50 or EC50	0.1
Acute Endangered Species	EEC/LC50 or EC50	0.05
Chronic Risk	EEC/NOAEL	1

[1] EEC = (ppm or ppb) in water

Risk Presumptions for Plants

Risk Presumption	RQ	LOC
	Terrestrial and Semi-Aquatic Plants	
Acute High Risk	EEC[1]/EC25	1
Acute Endangered Species	EEC/EC05 or NOAEC	1
	Aquatic Plants	
Acute High Risk	EEC[2]/EC50	1
Acute Endangered Species	EEC/EC05 or NOAEC	1

[1] EEC = lbs ai/A
[2] EEC = (ppm or ppb) in water

b. Summary of Risks to Nontarget Organisms

Terrestrial and Aquatic Field Studies Demonstrate Adverse Effects to Non-target Organisms

Three extensive terrestrial field studies on corn in Iowa, citrus in California, and golf courses in central Florida, report cholinesterase-inhibition effects and chlorpyrifos-related mortality in non-target organisms. Chlorpyrifos-related mortalities were reported in small mammals, birds, snakes, an aquatic turtle, and amphibians as determined by measureable chlorpyrifos residues in the carcasses. Other non-target organisms were observed showing behaviors indicative of cholinesterase inhibition. And although these field studies did not include an aquatic application or require monitoring of aquatic areas, fish kills were reported in the citrus and golf course studies in aquatic habitats adjacent to treated areas.

Measured chlorpyrifos levels on foliage samples and water samples reported in all three studies generally exceed the EFED predicted, foliar and aquatic EECs for respective application rates. These chlorpyrifos residue levels also exceed the LC_{50} and/or EC_{50} values for mammals, birds, fish and aquatic invertebrates.

Aquatic field studies where chlorpyrifos has been applied directly to water for insect control have

shown adverse effects on non-target species, including fish recruitment and growth and near elimination of some aquatic invertebrate populations. Chlorpyrifos-related mortalities identified in the three field studies confirm estimates of high risks to both terrestrial and aquatic wildlife from chlorpyrifos uses.

Incident Records Confirm Adverse Effects to Non-target Organisms

Incident reports indicate song bird kills and occasional fish kills mostly associated with termite applications, particularly perimeter treatments. Wildlife incidents associated with lawn care treatment with chlorpyrifos for soil insect control include the deaths of robins, starlings, sparrows, geese, goslings, a bluebird, a cat, and fish. In some cases, other pesticides, such as diazinon, are also present. Huang *et al*. (1994) conclude that the toxicity of chlorpyrifos and diazinon are additive (not synergistic) to aquatic organisms. Toxicity of two chemicals A and B are additive, if the concentrations of [A] and [B] yield increased toxicity, such that $1/[LC_{50}$ of AB] = $1/[LC_{50}$ of A] + $1/[LC_{50}$ of B]. In most incident cases, the lawns had been sprayed with a liquid formulation of chlorpyrifos. The largest wildlife incidents are associated with 15-foot wide, perimeter treatments following termiticide treatments of buildings. Approximately 75 robins were killed in a single incident in Daytona Beach, FL; 32 robins were killed in Tennessee; and 24 robins were killed in Georgia. Fish kills have also been reported for termite control treatments. In one incident 2,000 small bluegill sunfish were killed in a lake adjacent to two motel rooms which had been treated for termites. The use of chlorpyrifos on golf courses has been associated with the deaths of 35 geese in one incident and 8 geese in another. In some cases, another pesticide like diazinon, may also be present. As mentioned earlier, the acute toxicity of diazinon has been shown to be additive to chlorpyrifos toxicity.

Risk Quotients Exceed LOCs for Non-target Organisms

Chlorpyrifos is used extensively as an insecticide on most U.S. crops and also has many non-crop uses, which have not been studied or monitored for non-target wildlife effects. Risk quotients have been determined for most agricultural uses and some non-crop uses such as perimeter treatments for termites and golf courses. EECs have not been calculated for some uses, such as nursery uses that are sprayed until runoff and eartags on cattle. Risk quotients have been estimated based on maximum use rates and maximum seasonal poundage permitted by the label. For multiple applications, chlorpyrifos residues are additive using minimum retreatment intervals (7 days, if not specified on the product label) and appropriate half-lives for soils, foliage and water. Risk quotients have also been calculated for typical use rates identified by BEAD for select major crop uses.

Risk quotients indicate that a single application of chlorpyrifos poses high risks to small mammals, birds, fish and aquatic invertebrate species for nearly all registered outdoor uses. Multiple applications increase the risks to wildlife and prolong exposures to toxic concentrations. In most cases, acute risk quotients exceed 1 for the most sensitive, small mammals and birds. All aquatic acute and reproductive risk quotients (using GENEEC and/or PRZM/EXAMS EECs for the edge of the field ponds) exceed 1 and frequently some aquatic risk quotients exceed 10 and 100. In the

case of the maximum use rate on tobacco, both acute and reproductive risk quotients for estuarine invertebrates exceed 1,000. In a few cases at maximum application rates, chlorpyrifos may bioconcentrate in the tissues of fish and aquatic invertebrates to levels that result in bioaccumulations which exceed acute LC_{50} values for sensitive bird species and reproductive NOAEC for birds and small mammalian species. Hence bioconcentration of chlorpyrifos in ponds and estuarine areas may pose acute and/or reproductive risks to aquatic birds and mammals feeding adjacent to treated areas. The assessment that wildlife are at risk is supported by the occurrence of deaths and adverse effects on wildlife reported in the three field studies for both spray and granular applications of chlorpyrifos.

c. Risks to Specific Groups of Nontarget Organisms

(i) Risks to Terrestrial Mammals

Risk quotients for both maximum and typical use rates exceed the levels of concern for small mammalian herbivores and insectivores for most crop and non-crop uses of chlorpyrifos. The high risk LOC (0.5) for the mammalian acute oral LD_{50} values is usually exceeded for 15 gram mammals, frequently exceeded for 35 gram mammals and occasionally exceeded for 1000 gram mammals. The high risk LOC (0.5) for mammalian subacute dietary LC_{50} is rarely exceeded, but the restricted use LOC (0.2) is exceeded frequently. The LOC for reproductive effects (1.0) is usually exceeded. Deaths of several small mammals and behavior consistent with cholinesterase inhibition in field studies are indicated by positive chemical analyses made for chlorpyrifos residues in carcasses as a result of both spray and granular chlorpyrifos applications.

(ii) Risks to Terrestrial Birds and Reptiles

Risk quotients for both maximum and typical application rates for spray uses usually exceed the levels of concern for high risks (0.5) for subacute LC_{50}s and (1.0) for reproduction NOAEL for avian species. Risk quotients for both maximum and typical application rates for granular uses usually exceed the level of concern for high risks (0.5) for acute oral LD_{50}s. Results from the three terrestrial field studies on corn, citrus and golf courses and several incidents with robins and other bird species reported for lawn and residential perimeter treatments associated with termiticide uses, support risk quotient assessments of risks to both birds and reptiles from chlorpyrifos uses.

Chlorpyrifos-treated fields are unlikely to produce the large visible bird kills, like those reported for carbofuran and some other fast-acting insecticides, which is not to say that many birds are not killed by chlorpyrifos. In the chlorpyrifos acute oral tests, the onset of avian symptoms predominately occurred between 20 minutes and 4 hours after dosing and deaths occurred within 24 hours. Thus, birds have adequate time to feed in chlorpyrifos-treated fields, leave the treated area and disperse to other habitats before they begin to experience toxic symptoms, then they seek refuge and hide before dying. The probability of finding dead wildlife is strongly reduced based on the average carcass recovery rate in habitats adjacent to corn (i.e., 5.8 percent recovery) and reported predation and removal rates of carcasses in the golf course study (i.e., 50 percent in 2

days and 99 percent in 4 days). The only way to determine the extent of avian deaths for chlorpyrifos under field conditions is to monitor mortality in field studies using radiotelemetry to determine the fate of each bird.

Sensitivity of reptiles to pesticides is assumed to be similar or less sensitive than birds, hence the avian risk quotients apply to reptiles as well. Some snake carcasses tested positive for chlorpyrifos in two of the three field studies. The presence of chlorpyrifos in snake carcasses suggests secondary toxicity (i.e., death caused by a chemical present in the carcass of an animal eaten by the predator). The likelihood of secondary toxicity of chlorpyrifos increases the potential of risks to numerous carrion-eating animals from chlorpyrifos use. Carrion feeders would include such animals as owls, peregrine falcon, golden eagle, bald eagle, crows, ravens, vultures, condors, coyotes, foxes, raccoons, skunks, and some snakes.

(iii) Risks to Bees and Beneficial Insects

Chlorpyrifos is highly acutely toxic to honey bees and applications would be expected to pose a risk to bees and beneficial insects present in the treated area during application. At present, there is no accepted method to determine risk quotients based on the bee acute contact toxicity data. Results from some field studies confirm predicted risks to bees, which are killed if present during application and for as long as 24 hours after treatment.

(iv) Risks to Earthworms

Chlorpyrifos applications may pose a slight risk to earthworm populations. Field studies indicate consistent reductions in the number of earthworms and earthworm biomass following an application of 2 lb ai/A of an 2 EC formulation. The results in these studies were reported as statistically insignificant ($P < 0.05$). Higher application rates than 2 lbs a.i./acre listed on labels may yield greater effects on earthworm populations than indicated by the results of this study.

(v) Risks to Fish and Amphibians

Risk quotients exceed the levels of concern for high acute toxicity (0.5) and chronic effects (1.0) for freshwater and estuarine fish for all uses. Comparison of peak EECs for 14 major crop uses presented in a table in the Surface Water Assessment section to the aquatic acute toxicity values indicates that the six out of fourteen peak EECs exceed the LC_{50} values for the four most sensitive freshwater fish species. Risks to some amphibian tadpoles are assumed to be greater than for the most sensitive fish species, since they are equally sensitive to chlorpyrifos and live in shallower waters.

Reproductive risks to fish populations are indicated by risk quotients which are greater than 21-day EECs for all uses. Fish reproductive effects are likely to be greater than indicated by RQ values presented in risk quotient tables for all chlorpyrifos uses. The fathead minnow tested in the full life-cycle study is approximately 100X less sensitive acutely than other fish species, such as bluegill and trout. Using an acute-to-chronic ratio to estimate a bluegill reproductive NOAEC,

the ratio yields an estimated NOAEC value of 0.005 ppb for bluegill. Since the fathead minnow NOAEC was used in the risk tables, the risk quotients for more sensitive fish species would be expected to be greater then estimated in the risk tables. The risk quotients for fish reproductive NOAEC might be as much as 100-fold times greater than the value cited in the risk tables.

Fish kills associated with chlorpyrifos terrestrial field studies on citrus and golf courses and some incident reports, usually associated with termiticide treatments of residential buildings, support conclusions of adverse effects on fish as suggested by risk quotients. Also chlorpyrifos levels monitored in some water samples collected from aquatic habitats adjacent to chlorpyrifos-treated corn, citrus, and golf courses exceed their respective EECs used to estimate the fish risk quotients. In fact, at least one water sample per study had measured chlorpyrifos levels equal to or exceeding the bluegill LC_{50} value. Another assessment can be made by comparing chlorpyrifos levels in the microcosm, mesocosm, and aquatic field studies to control mosquito larvae and other aquatic pests where adverse effects have been found, to EECs used to determine the fish risk quotients (see additional information on effects under the section on Field Monitoring Studies below).

(vi) Risks to Aquatic Invertebrates

Risk quotients for all uses exceed the levels of concern for high toxicity (0.5) for acute toxicity and chronic toxicity (1.0) for freshwater and estuarine invertebrates for outdoor uses assessed in this document. Risk quotients for estuarine invertebrate reproduction are likely to underestimate the risks, because a NOAEC was not obtained in the mysid life-cycle study. Comparison of peak EECs for 14 major crop uses presented in a table in the Surface Water Assessment section to EC_{50}/LC_{50} values for the four freshwater invertebrates indicates that the eight out of the fourteen peak EECs exceed the EC_{50}/LC_{50} values for three out of the four freshwater species. The acute and reproductive risks to the sensitive aquatic invertebrate species are expected to last long term. Predictions of long term effects are consistent with population effects on some invertebrate species observed in aquatic field studies. No aquatic invertebrate observations were made following applications of chlorpyrifos to terrestrial, crops or non-crop uses. The estuarine mysid shrimp is even more sensitive to chlorpyrifos than freshwater invertebrate species.

Reports of aquatic invertebrate kills are relatively rarely observed, probably because invertebrates do not have swim bladders and do not float to the surface like many fish species. Aquatic invertebrates are also less likely to be found because they are small, usually colored to hide in their habitat, and are quickly eaten by predators. Although no dead aquatic invertebrates were reported in the fish kills associated with chlorpyrifos terrestrial field studies on citrus and golf courses, chlorpyrifos levels monitored in some water samples collected from aquatic habitats adjacent to chlorpyrifos-treated corn, citrus, and golf courses, exceed their respective EECs and equal or exceed the acute EC_{50} values for many invertbrate species. Another assessment can be made by comparing chlorpyrifos levels in the microcosm, mesocosm, and aquatic field studies to control mosquito larvae and other aquatic pests where adverse effects have been found, to EECs used to determine the fish risk quotients (see additional details in the section below).

(vii) Risks to Freshwater Organisms in Field Monitoring Studies

Chlorpyrifos levels were measured in aquatic areas adjacent to treated fields in three field studies. In the Iowa corn field study, mean measured, chlorpyrifos residue levels in water samples ranged from non-detect to 66.9 ppb and as high as 115 ppb adjacent to spray treated fields. The measured 66.9 ppb level exceeds all predicted EECs which range from 6.8 to 24 ppb. In the granular-treated corn field study, only one water sample had measurable chlorpyrifos levels (1.80 ppb) which was sampled seven days after the tassel broadcast treatment. The measured 1.80 ppm concentration is less than predicted EECs that ranged from 5.5 to 8.6 ppb. In the California citrus field study, some measured chlorpyrifos residue levels in water samples also exceeded predicted EECs (i.e., mean measured levels ranged from non-detected to 244 ppb versus predicted EECs which range from 7.6 to 29.7 ppb). Measured chlorpyrifos residues of up to 2.55 ppb were found in water samples taken from aquatic areas adjacent to granular-treated turf in the central Florida golf course field study.

In the California citrus field study, dead fish and other aquatic vertebrates were found in ponds adjacent to treated groves on several occasions. Dead fish were also found in ponds adjacent to treated golf courses in a central Florida field study. While there were no reported fill kills reported in the corn field study, chlorpyrifos was measured in water samples collected adjacent to 4 out of 8 chlorpyrifos-treated fields. Measured chlorpyrifos residues in water adjacent to treated corn fields were as high as 115 ppb (almost 100 times the bluegill LC_{50} value and 1,000 times the aquatic invertebrate EC_{50} value).

Monitoring studies have found chlorpyrifos residues in fish nationwide and in water regionally. Results from a national fish monitoring study by the Office of Science and Technology indicates that 20 percent of the fish nationwide had measurable levels of chlorpyrifos residues (EPA 1992). The NOAA (1992) document on Agricultural Pesticide Use in Coastal Areas: A National Summary reports 2.3 - 59 ppb chlorpyrifos in mussels in coastal California, 245 ppb in sediments in Buzzards Bay, MA. Storet reports measurable chlorpyrifos levels in biota in 12 states and in one water sample. These monitoring results indicate widespread and persistent occurrence of chlorpyrifos in aquatic areas throughout the nation. While these results should raise concerns, it is uncertain whether the chlorpyrifos levels in aquatic organism tissues are sufficient to adversely affect exposed organisms. Risks to benthic organisms exposed to chlorpyrifos sorbed to soils and sediments (K_{oc} 6070) have not been assessed. Currently, requirement of sediment toxicity tests are infrequent and sediment toxicity studies have not been voluntarily submitted.

In a California Control Board Memorandum from Val Connor (dated Dec. 13, 1996, unpublished), chlorpyrifos was reported to exceed the California Department of Fish and Game water quality criterion of 15 ng/L (pptr) in monitoring data from 1994 to 1995 for urban storm runoff episodes collected in receiving waters in the San Francisco Bay area. Out of ninety receiving water samples collected from Sacramento and Stockton, approximately 80 percent of these samples exceeded the California water quality criteria. In the San Francisco Bay area, approximately 75 percent of the 46 samples collected exceeded the water quality criterion. Rainfall samples also collected in the San Francisco area contained chlorpyrifos at levels toxic to

Ceriodaphnia. In another California monitoring study (California Central Valley Regional Water Quality Control Board, dated Dec. 1995, unpublished), chlorpyrifos residues exceeded water quality criterion about half the time in agricultural areas along a 43-mile reach of the San Joaquin River between the confluence of the Merced and Stanislaus Rivers during 1988-90. During the 1991-92 monitoring period, 45 percent of the water samples collected from the Turlock Irrigation District Lateral (canal) Number 5 (TID5) on the east side of the valley contained chlorpyrifos which tested toxic to *Ceriodaphnia*. On the west side of the valley, 22 percent of the water samples from Orestimba Creek had chlorpyifos levels which tested toxic to *Ceriodaphnia*. In this study, chlorpyrifos was found more frequently in water samples than any other pesticide (i.e., detected 85 times and 18 samples had concentrations which are toxic to *Ceriodaphnia*). Diazinon was the second most frequently found pesticide measured 81 times with 4 toxic samples. Almost half of all water samples analyzed during the 1991-92 study for pesticides (toxic and non-toxic) contained both chemicals and the toxicity of the two are additive (Huang *et al*. 1994).

(viii) Risks to Piscivorous Birds and Mammals from Bioconcentration of Chlorpyrifos in the Food Chain

For high application uses, chlorpyrifos levels in fish and aquatic invertebrates are estimated to exceed the avian subacute dietary toxicity value (136 ppm) and reproductive NOAELs for birds (25 ppm) and mammals (10 ppm) for some uses.

Levels of chlorpyrifos in fish and aquatic invertebrates may be underestimated, because residues were calculated for uptake only from water and do not include dietary or sediment exposures. Prey species would also be expected to bioaccumulate chlorpyrifos and pose an alternative exposure to predators.

(ix) Risks to Nontarget Plants

Risks to non-target terrestrial plants can not be assessed for chlorpyrifos, because toxicity studies are not required for insecticides. The Science Advisory Panel has recently approved testing requirements for non-target plants for insecticides. These tests will be required when 40 CFR Part 158 is revised and published.

Toxicity data are available for only one out of five recommended aquatic plant species. Based on toxicity values for three estuarine algal species (only one recommended species), risk quotients for the highest exposures do not exceed any level of concern. However, the EC_{50} for all three algal species were exceeded by measured chlorpyrifos levels in some water samples found in the citrus field study. Assessment of risks to other aquatic plant species is deferred until those studies are submitted. Testing of aquatic plants will also be required for insecticides, when 40 CFR Part 158 is revised and published.

(x) Risk Characterization of Chlorpyrifos' Major Degradate

EFED has identified a number of degradates/metabolites for chlorpyrifos. The major degradate

was identified as 3,5,6-trichloro-2-pyridinol. A full set of acute studies have been submitted. The acute toxicity values indicate that the major degradate ranges from moderately toxic to practically non-toxic. Degradate toxicity values are as follows: LD_{50} for bobwhite > 2,000 mg/kg; mallard LC_{50} > 3,316 ppm; bluegill 12.5 ppm; rainbow trout 12.6 ppm; daphnids 10.4 ppm; Atlantic silverside LC_{50} 58.4 ppm; grass shrimp LC_{50} 83 ppm; and eastern oyster shell deposition LC_{50} 9.3 ppm. In all cases, the major degradate is less acutely toxic than chlorpyrifos, hence risks to fish and wildlife would appear to be reduced as chlorpyrifos degrades.

d. Select Toxicity Values for Risk Assessment

(i) Toxicity Values and Toxicity Conversions

The acute toxicity of chlorpyrifos is well characterized for a wide variety of wildlife species. Reproduction studies are available for the normal array of terrestrial and aquatic species. The following toxicity values were selected as the most sensitive endpoints for each test type.

(a) Mammalian Toxicity Values and Conversions

The lowest mammalian acute LD_{50} value is 97 mg/kg for rats (0.40 kg body weight). One-day LC_{50} values were calculated for small to medium-sized mammals of various sizes and dietary preferences (see table below). The lowest subacute 5-day dietary LC_{50} value is 1330 ppm for rats. A NOAEL from a two-generation rat reproduction study is 1 mg/kg/day (10 ppm for the young). Reduced pup body weight and increased mortality in young are the most sensitive mammalian reproductive endpoints.

Assessment of risks to small mammals using the residues on food items requires that the acute oral LD_{50} values be converted to estimate LC_{50} values for dietary exposure. LC_{50} values were estimated for a variety of small to medium-sized mammals having different dietary needs using the following formula:

$$\text{1-day } LC_{50}\text{(mg/kg/day)} = \frac{LD_{50}\text{ (mg/kg) x body wt.(kg) x 100\%}}{\text{\% body wt. eaten/day x body wt.(kg)}}$$

Mammalian Species	Body Weight (g)	% Body Wt Consumed per day	Rat LD50 mg/kg	Est. 1-day LC50 ppm
Herbivores/Insectivores	15 35 1000	95 66 15	97	102 147 647
Granivores	15 35 1000	21 15 3	97	462 647 3233

In order to assess risk, these estimated mammalian 1-day LC_{50} values are divided into the appropriate residues for the respective food type to calculate a risk quotient (i.e., EEC/LC_{50}).

Each risk assessment table provides exposures and the toxicity values for various surrogate species used to calculate the risk quotients for wildlife groups for the crop(s), application rate, and use methods specified in the table heading. In determining dietary risks to terrestrial species, a range of dietary exposures are assessed to cover a range of items in the diet. For example, a herbivore may feed on foliage at 135 ppm per 1 lb ai/A and short grass at 240 ppm per 1 lb ai/A. The extent to which a species prefers one or the other food item, and actually feeds on treated food, will determine risk.

(b) Avian Toxicity Values

The following toxicity values were selected as the most sensitive avian endpoints. The avian acute LD_{50} value used is 10 mg/kg for the house sparrow (times O.0277 kg body weight) which is equivalent to a LD_{50} dose of 0.277 mg versus 0.641 mg for the common grackle (LD_{50} 5.62 mg/kg X 0.114 kg). The lowest avian subacute dietary LC_{50} value is 136 ppm for mallard ducks. The mallard duck is the most sensitive avian species tested with a reproductive NOAEL of 25 ppm based on significant 84% reduction in the number of eggs laid; 40% and 16% reductions in drake and hen survival, respectively; 9% reduction in eggshell thickness; and 89% fewer young.

(c) Freshwater and Estuarine Toxicity Values

The following toxicity values were selected as the most sensitive aquatic endpoints for freshwater and estuarine species of fish and invertebrates. These aquatic toxicity values used are an acute LC_{50} value of 1.8 ppb for bluegills; a NOAEC of 0.57 ppb for fathead minnow reproduction (14% reduction in F_0 survival and 35% reduction in F_1 survival at 1.09 ppb); an acute LC_{50} value of 0.10 ppb for daphnids and a NOAEC of 0.04 ppb for daphnid reproduction (100% reductions in adult survival and number of offspring).

The estuarine/marine toxicity values identified as the most sensitive endpoints are an acute LC_{50} of 0.96 ppb for silversides, a fish; a NOAEC of 0.28 ppb for silverside reproduction (74% reduction in young survival); an acute LC_{50} of 0.035 ppb for mysid shrimp; and a NOAEC of less than 0.0046 ppb mysid reproduction (85% reduction in the number of young).

(d) Piscivore Toxicity Values and Bioconcentration Factors (BCF) Values

The toxicity values for determining risk from exposures resulting from bioconcentration are the same subacute and chronic toxicity values used in the terrestrial risk assessment. Laboratory studies show that chlorpyrifos bioconcentrates in fish with BCF values of 2730X for whole fish, 3900X for fish viscera, and 1280X for fish edible tissues (i.e., fish fillet). An oyster study yielded BCF values of 2500X in oyster tissue, 1900 in whole oyster, and 87X in oyster liquor. Since predatory mammals and birds usually eat the soft viscera prior to eating the muscle or eat its prey whole, the exposure levels in fish and aquatic invertebrates used to assess risks are calculated using the fish viscera and whole fish BCF values.

(e) Plant Toxicity Values

Toxicity studies were unavailable for chlorpyrifos to terrestrial plants. Toxicity data are available on only two aquatic plant species. The most sensitive algal EC_{50} value is 140 ppb.

e. Ecological Exposures and Risk Characterization

Chlorpyrifos is registered for spray and granular applications on many crops and has many non-crop uses. Wildlife risks are assessed for maximum registered chlorpyrifos use rates for crops and such non-crop applications as lawn care and other outdoor pest control uses. Maximum use rates on crops range from 0.5 to 6 lbs ai/A for a single application. Multiple applications are registered on many crops with up to 22 applications on sweet corn in some states. Wildlife risks also are assessed for typical use rates identified by the Biological and Economic Analysis Division (BEAD) for major crop uses.

(i) Risk Assessments for Corn

The risk assessment for chlorpyrifos use on corn is addressed separately from other crops, because chlorpyrifos use on corn represents such a large part of the total chlorpyrifos poundage used on U.S. crops. Also, corn applications are diverse and pose some unique routes of exposure to terrestrial wildlife.

Chlorpyrifos can be applied to corn seed and corn at all stages of growth. Four chlorpyrifos formulations are applied to field corn, sweet corn, popcorn, or corn grown for seed. These formulations are Lorsban 4 EC and three granular formulations (0.5% G, 1% G and 15% G). Chlorpyrifos formulations used on corn are Lorsban 15 G which is the primarily used for pre-plant and at-plant applications and Lorsban 4 EC. The 0.5% G and 1% G formulations are for homeowner use. Chlorpyrifos is applied to about 7 percent (8% is the likely maximum) of the approximate 71,260,000 acres of corn in the US.

Chlorpyrifos uses on corn include applications: to stored and preplant seeds (slurry treatments with 50% WP only); preplant with soil incorporation (4 EC and 15 G); at plant, in band treatments (4 EC and all four granular formulations) and in-furrow (15 G); preemergence broadcast (4 EC); at cultivation side-dress (4 EC and 15 G); and postemergence broadcast (4 EC and 15 G). Chlorpyrifos use pattern data were obtained from the use information used by HED for crops and provided by Dow for non-food uses. Application rates on corn, number of applications, and minimal time interval between treatments are summarized below in a table for each formulation, in order to easily compare risks for each growth stage for different use rates and formulations.

Application Type and Application Method	Chlorpyrifos Formulation	Application Rates (expressed as ai)	Maximum Number of Applications	Maximum lb ai/A per Season	Treatment Interval (days)

Seed Treatments:					
Stored Seeds:	50 % WP	1 oz. ai./100 lbs. of seed	1	NA	NA
Preplant Seed:		1 oz. ai./100 lbs. of seed	1	NA	NA
Pre-plant:	4 EC	1 lb/A in ≥ 10 gal./A	1	NA	NA
Broadcast	(2-4")	2 lb/A in ≥ 10 gal./A	1	NA	NA
		3 lb/A in ≥ 10 gal./A	1	NA	NA
(Soil Depth of	15 G	1 lb/A	1	NA	NA
Incorporation)	(4-6")	2 lb/A	1	NA	NA
At Plant:	4 EC	1 lb/A in ≥ 20 gal.	1	NA	NA
Broadcast		2 lb/A in ≥ 20 gal.	1	NA	NA
At Plant:	0.5 G	2.4 oz/ 1,000 ft.	1	NA	NA
Soil Band	1 G	2.4 oz/ 1,000 ft.	1	NA	NA
Soil incorporated	15 G	1.2 oz/ 1,000 ft.	1	NA	NA
0.5 to 2" deep	(6-7" wide)	1.8 oz/ 1,000 ft.	1	NA	NA
(15% available)	(6-7" wide)	2.4 oz/ 1,000 ft.	1	NA	NA
	(7-10" wide)	2.4 oz/ 1,000 ft.	1	NA	NA
At Plant:	15 G	1.2 oz/ 1,000 ft.	1	NA	NA
In-furrow	(assume	1.8 oz/ 1,000 ft.	1	NA	NA
(1% available)	6" wide)				
Preemergence:	4 EC	0.25 lb/A in ≥ 20 gal.	1	NA	NA
Broadcast		0.5 lb/A in ≥ 20 gal.	1	NA	Na
Cultivation:	4 EC	1 lb/A	1	NA	NA
Sidedress	15 G	0.9 oz/ 1,000 ft.	1	NA	NA
		1.2 oz/ 1,000 ft.	1	NA	NA
Postemergence:	4 EC	0.25 lb/A in 20-40 gal.	1	7.5 lb/A	as needed
Broadcast			2		(assume 7)
(ground spray		0.5 lb/A in 20-40 gal.	1	7.5 lb/A	as needed
in 20-40 gal.)			2		(assume 7)
or		1 lb/A in 20-40 gal.	1	7.5 lb/A	as needed
(aerial spray			2		(assume 7)
in sufficient water)		1.25 lb/A in 20-40 gal.	1	7.5 lb/A	as needed
			2		(assume 7)
		1.5 lb/A in 20-40 gal.	1	7.5 lb/A	as needed
			2		(assume 7)
(ground & aerial)	15 G	0.75 lb/A	1	2.025 lb/A	as needed
			2		(assume 7)
		0.975 lb/A	1	2.025 lb/A	
			2		
Sweet Corn:	4 EC	0.5 lb/A	22	11 lb/A	as needed
(FL & GA only)	(aerial 2 gal.)				(assume 3)
Broadcast		1 lb/A	11	11 lb/A	"
	4 EC	0.5 lb/A	22	11 lb/A	"
	(ground)	1 lb/A	11	11 lb/A	"

Seed Treatments (Stored and at Plant):

Seed treatment of corn with chlorpyrifos may result in several routes of exposure leading to risk concerns for wildlife. Birds and small mammals may feed on treated corn kernels in storage, treated corn kernels left exposed on top of the soil after planting, or remaining residues in young corn sprouts. Corn seed may be consumed by birds and small mammals in single feedings resulting in acute effects or as continuous dietary exposures for short or long periods. Treated corn kept in storage areas may be available to birds and small mammals, such as sparrows, mice, rats, etc., which enter storage areas. While toxic effects on these species are assessed here, death of these species may be of little or no concern to society, because grain losses due to wildlife may require pest control efforts to prevent loss.

Stored Seed Treatment for Corn Uses: Stored corn seed may be treated with chlorpyrifos (50% WP) at 0.038 - 0.076 oz. (0.019-0.038 oz. a.i.) per 100 lbs of seed, as an aqueous solution of 12 to 24 ppm (6 to 12 ppm a.i.). The following stored seeds may be treated at the same rates: field beans, green beans, kidney beans, lima beans, navy beans, snap beans, string beans, wax beans, field corn, sweet corn, cucumbers, black-eyed peas, field peas, garden peas, and pumpkins. The 24 ppm rate will provide a longer period of protection. The formulae used to calculate exposures and risk quotients for treated seeds are listed below. Chlorpyrifos application rate and risk quotients (RQ) are summarized in the following table.

$$LD_{50}\ RQ = \frac{\text{(oz. ai/100 lb) X 28,340 mg/oz.}}{\text{100 lb X (LD50 X kg body wt.)}}$$

$$LC_{50}\ RQ = \frac{\text{(oz. ai/100 lb) X 28,340 mg/oz.}}{\text{100 lb X 0.4535 kg/lb X (LC50 or NOAEL)}}$$

Application Type and Application Method	Chlorpyrifos Formulation	Application Rates (expressed as ai)	Maximum Number of Applications	Maximum lb ai/A per Season	Treatment Interval (days)	Risk Quotients Bird Mammal Acute / Chronic Acute / Chronic
Stored Seed Treatment	50 % WP	0.038 oz/100 lb	1	NA	NA	Acute Oral LD*50*s 39 / -- 0.56 / -- Dietary LC_{50}s and Chronic NOAECs 0.17 / 25 0.02 / 2.4

Risk quotients for Stored Seed Treatment: Risks to wildlife consuming stored seed corn treated with chlorpyrifos are high to birds for acute and chronic exposures and high to small mammals for acute and chronic exposures. Levels of concern are exceeded by treated stored seeds, but concern for likely consumers: mice, rats and pigeons is low because these pests would likely have to be baited to control, if the seed were not toxic to these pests.

Treated Seed at Planting Uses: During planting, chlorpyrifos-treated corn kernels and other seeds may be accidently scattered on the soil surface, especially when the planter is withdrawn from the soil at the end of a row. Since the kernels are planted in-furrow, it is assumed that only 1 percent of the kernels are exposed during planting, which assumes the same percentage as for the exposed granules when placed in-furrow. Chlorpyrifos 50 WP (50 % a.i.) is applied to preplant seed corn and other seeds at 2 oz. (1 oz. a.i.) per 100 lbs of seed (2 oz. a.i. for cotton seed). It is assumed that the corn planting rates are 18 to 20 lbs/A for field corn, 8 to 16 lbs/A for sweet corn, and 3 to 6 lbs/A for popcorn. The formulae presented below give risk quotients for acute effects from consuming treated corn seed; acute exposure to exposed kernels in the field per square foot; and subacute dietary and reproductive effects from exposed kernels. The risks are assessed in the following table.

$$LD_{50}\ RQ = \frac{\text{(oz. ai/100 lb) X 28,340 mg/oz.}}{\text{100 lb X (LD50 X kg body wt.)}}$$

$$LC_{50}\ RQ = \frac{\text{(oz. ai/100 lb) X 28,340 mg/oz.}}{}$$

100 lb X 0.4535 kg/lb X (LC50 or NOAEL)

Application Type and Application Method	Chlorpyrifos Formulation	Application Rates (expressed as ai)	Maximum Number of Applications	Maximum lb ai/A per Season	Treatment Interval (days)	Risk Quotients Bird Mammal Acute / Chronic Acute / Chronic
Preplant Seed Treatment	50 % WP	1 oz./100 lb	1	NA	NA	Acute Oral LD*50*s 1020 / -- 14 / -- Dietary LC_{50}s and Chronic NOAECs 4.6 / 25 0.47 / 62

An alternative method to assessing risks using risk quotients is to estimate the number of chlorpyrifos-treated corn kernels equivalent to the acute oral LD_{50}. The formula to calculate the number of seeds per mg of chlorpyrifos is presented below. And the following table indicates the number of corn kernels equivalent to the acute oral LD_{50} for some select wildlife species.

$$\text{mg ai/corn kernel} = \frac{\text{(oz. ai/100 lb) X 28,340 mg/oz.}}{\text{3 corn kernels/g X 1000 g/kg X 100 lb X 0.4535 kg/lb}}$$

At-plant Risks to Wildlife Expressed as RQs per Kernel and Number of Kernels per LD_{50}
(Assumes 0.2 mg ai per corn kernel when treated at 1 oz. ai/ 100 lbs of corn seed)

Species	**LD_{50} (mg/kg body wt.)**	**Body Weight (kg)**	**RQ / Kernel**	**Kernels / LD_{50}**
House Sparrow *Passer domesticus*	10	0.0277	0.72	1.4
Common Grackle *Quiscalus quiscula*	5.62	0.114	0.31	3.2
Red-winged Blackbird *Agelaius phoeniceus*	13.1	0.0526	0.29	3.4
Mammal (15 grams body wt.)	97	0.015	0.14	7.3
Japanese Quail *Coturnix japonica*	13.3	0.178	0.084	12
Rock Dove *Columbia livia*	26.9	0.100	0.074	13
Mammal (35 grams body wt.)	97	0.035	0.059	17
Common Pigeon *Columba livia*	10	0.040	0.050	20
Bobwhite Quail *Colinus virginianus*	32	0.178	0.035	28
Starling *Sturnus vulgaris*	75	0.0823	0.032	31
Ring-necked Pheasant *Phasianus colchicus*	8.41	1.135	0.021	48
Rat *Rattus norvegicus*	97	0.200	0.010	97
Cockerel *Gallus domesticus*	34.8	1.500	0.0038	261

Mallard Duck *Anas platyrhynchos*	75.6	1.082	0.0024	409
Mammal (1000 grams body wt.)	97	1.000	0.0021	485

Risk Summary for Preplant Seed Treatment for Corn: Preplant treatment of seed corn with Lorsban 50 WP may pose high risks to birds and small mammals. Each corn kernel contains an average of 0.20 mg chlorpyrifos. If treated kernels are consumed by wildlife, the acute risk quotients from a single kernel is a high risk (LOC $\geq$ 0.5) to house sparrows (RQ = 0.72) and a moderate-to-low risk to small mammals (RQ = 0.14). The LOC (0.1) for endangered species is exceeded for four species eating a single corn kernnel. Some avian species, such as crows, which pull up and eat young corn sprouts, are also exposed to chlorpyrifos in the sprout. However, chlorpyrifos concentrations in the sprout will be reduced to an unknown degree as a result of leaching and/or degradation. Hence, risks to species feeding on young sprouts will be less than if they feed on the corn kernels.

The number of treated kernels which are equivalent to LD50 values were calculated for several wildlife species for which there are LD50 values. The number of treated corn kernels with chlorpyrifos levels equivalent to LD50 doses are 1.4 kernels for house sparrows, 3.2 for common grackles, 3.3 for red-winged blackbirds, etc.. It is reasonable to expect that sparrows are liable to eat exposed corn kernels by pecking kernels into smaller pieces and could be at risk. Other species such as the common grackle, red-winged blackbirds, and rock doves could easily consume enough kernels to be killed. For some less sensitive species, such as mallard ducks, it is uncertain whether they could eat enough kernels to be affected. Since the amount of exposed corn kernels necessary to equal the LD_{50}s are within about 16 percent of their body weight, it is possible for acute risk quotients for all species to be 1.0 or greater with a bit of gluttony. In summary, treated corn kernels pose a high potential risk to most or all avian species and small mammals.

Use of the LD_{50}/ft^2 criteria to assess wildlife risks appears to be inappropriate in the case of treated seeds at planting. If it is assumed that the per square foot area is a 1-inch wide band and 144 inches long and that corn is planted every four inches, only 36 seeds are planted in that 1 sq. ft. area. If it is assumed that an average of only 1 percent of the seeds are exposed as in the case for in-furrow granular applications, the exposure is 0.36 exposed seeds per square foot and the risks would appear low. However, birds are adept at finding seeds over large areas, and it is likely that individual birds will find several seeds spread over a larger area. Since only a few seeds are needed to exceed the LD_{50}s of some species, it would appear that the risks to these species may be high. Consequently, it would be inappropriate to assess risks to wildlife on a per square foot basis.

Corn Uses: Corn is the major crop use for chlorpyrifos. Chlorpyrifos is primarily applied to corn as a granular formulation (i.e., Lorsban 15G) and liquid formulation (i.e., Lorsban 4 EC). Lorsban 30G was registered on November 6, 1998; it unclear whether it has entered commercial use. Homeowner formulations include 0.5% and 1% granular formulations. It is unclear if the Lorsban 7.5 G formulation is still registered.

Chlorpyrifos is applied to corn for a total of about 7 percent (8 percent is likely maximum) of the approximately 71,000,000 acres of corn grown in the U.S. Directions for corn use on registered labels permit chlorpyrifos applications at the following stages: pre-plant, at-plant, postemergence, whorl, and tassel with a maximum seasonal use of 7.5 lbs ai/A. Chlorpyrifos applications may be made by ground, aerial, or sprinkler equipment. Registered labels for special state use allows 11 to 22 treatments at 0.5 to 1.0 lbs ai/A with a maximum seasonal use of 11 lbs ai/A. According to BEAD, the typical application on corn is an at-plant, granular treatment at 1.1 lbs ai/A for soil insects. The leading states using chlorpyrifos on corn in decreasing order of poundage are Illinois, Iowa, Nebraska, Indiana, Wisconsin and Ohio.

Wildlife utilization of corn fields is high with a broad diversity of avian and mammalian species. Wildlife reported to feed moderately to high in corn fields include quail, grouse, partridge, pheasant, prairie chicken, ducks, doves, songbirds (35 species), red fox, muskrat, opossum, raccoon, and deer to a low to high degree. While it is unlikely that deer might be adversely affected, because of their large size, many of the other species could be affected by consumption of food items (such as seeds, insects and vegetation) found in chlorpyrifos-treated cotton fields. Bobwhite quail, pheasant (brood-rearing), and rabbits also nest and brood young in corn fields. In the Iowa corn field study, the number of avian species observed in corn field in various replicates ranged from 12 to 24 species in six circular plots per field. The number of individual birds seen in corn replicates ranged from 50 to 110 birds. The number of birds observed in corn fields total 768 birds in the circular plots.

Risk assessments have been made using maximum application rates as an initial screen for effects followed by a refinement with typical usage. Risk quotients have been estimated for spray and granular treatment for all corn growth stages. Risk for uses in Iowa and Mississippi were assessed and indicate some regional differences in risks. Multiple applications were also assessed for risks from the accumulation of pesticide residues in terrestrial and aquatic systems. Risks for each usage are presented in tables below. Results from an Iowa, corn field study are presented, which, in general, support predicted EECs and adverse effects to birds and small mammals. Although, many dead animals were found, residue analysis was performed on only 9 birds and small mammals. Five animals (56 percent) tested positive for chlorpyrifos residues and one rabbit was found showing signs of cholinesterase inhibition, but it escaped capture.

Corn Preplant Spray Incorporation Use: Directions for corn use on registered labels allow chlorpyrifos (Lorsban 4 EC or 50% WP) to be sprayed by ground equipment at 1, 2 or 3 lbs ai/A mixed in a minimum of 10 gallons of water per acre followed by soil incorporated.

Terrestrial EECs were estimated using the maximum application rate and the residue levels identified by Hoerger and Kenaga (1972) as modified by Fletcher *et al*. (1994). While soil incorporation following spray applications may reduce the amount of treated vegetation, seeds, and insects that are available to wildlife on the surface, it is assumed that soil incorporation does not reduce the pesticide concentrations on the food items. Soil incorporation reduces the amount of pesticide available for runoff.

Aquatic EECs were modelled by EFED using the PRZM3.12-EXAMS model on Marshall silty clay loam soil in Pottawattamie Co., Iowa and local rainfall conditions. Risk quotients for wildlife and aquatic species exposed to the spray-treatment corn are presented in the following tables for easy comparison of wildlife risks for different formulations and different use rates in other tables.

Risk Quotients for Corn in Pottawattamie Co., Iowa
(Pre-plant Ground Spray; 1 Application at 3 lbs ai/A; 2-inch Soil Incorporation)
(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on PRZM3.12-EXAMS Model)

Species	Exposure	Toxicity	Risk Quotients
Mammalian Herbivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	405[1] - 720[2] ppm	102 ppm 147 ppm 647 ppm	4.0 - 7.1 2.8 - 4.9 0.63 - 1.4
Mammalian Insectivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	45[3] - 405[4] ppm	102 ppm 147 ppm 647 ppm	0.44 - 4.0 0.31 - 2.8 0.07 - 0.63
Mammalian Granivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	45[5] ppm	462 ppm 647 ppm 3233 ppm	0.097 0.070 0.014
Mammalian Subacute Dietary LC_{50}	45 - 720 ppm	1330 ppm	0.034- 0.54
Mammalian Reproduction NOAEL	45 - 720 ppm	10 ppm	4.5 -72
Avian Subacute Dietary LC_{50}	45 - 720 ppm	136 ppm	0.33 - 5.3
Avian Reproduction NOAEL	45 - 720 ppm	25 ppm	1.8 -29
Freshwater Fish Acute LC_{50}	2.75[6] ppb	1.8 ppb	1.5
Fish Reproduction NOAEC	1.28[7] - 2.18[8] ppb	0.57 ppb	2.2 - 3.8
Aquatic Invertebrate Acute LC_{50}	2.75 ppb	0.10 ppb	28
Freshwater Invert. Reproduction NOAEC	1.28 - 2.18 ppb	0.04 ppb	32 - 54
Estuarine Fish Acute LC_{50}	2.75 ppb	0.96 ppb	2.9
Estuarine Fish Reproduction NOAEC	1.28 - 2.18 ppb	0.28 ppb	4.6 - 7.8
Estuarine Invertebrate Acute LC_{50}	2.75 ppb	0.035 ppb	79
Estuarine Invert. Reproduction NOAEC	1.28 - 2.18 ppb	< 0.0046 ppb	>280 > 470
Estuarine Algae EC_{50}	2.75 ppb	140 ppb	0.020

[1] Upper residue level on foliage exposed in plowed field (135 ppm per lb ai/A applied)
[2] Upper residue level on short grasses exposed in plowed field (240 ppm per lb ai/A applied)
[3] Upper residue level on large insects (135 ppm per lb ai/A applied)
[4] Upper residue level on small insects (15 ppm per lb ai/A applied)
[5] Upper residue level on seeds and fruit (15 ppm per lb ai/A applied)
[6] Peak EEC in 2-meter deep pond or estuarine water
[7] 21-Day EEC in 2-meter deep pond or estuarine water
[8] 96-Hour EEC in 2-meter deep pond or estuarine water

Risk Summary for Maximum Preplant Spray to Corn: Chlorpyrifos ground sprayed pre-plant at 3 lbs ai/A and soil incorporated to 2 inches yields risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian

acute (0.014-7.1), subacute (0.034-0.54) and reproduction NOAEL (4.5-72), avian subacute (0.33-5.3) and reproduction NOAEL (1.8-29), freshwater fish acute (1.5) and reproduction NOAEC (2.2-3.8), aquatic invertebrate acute (28) and reproduction NOAEC (32-54), estuarine fish acute (2.9) and reproduction NOAEC (4.6-7.8) and estuarine invertebrate acute (79) and reproduction NOAEC (> 280 > 470). The algal risk quotient (0.020) does not exceed any level of concern.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 5 ppm and whole fish of 3.5 ppm. These levels in fish are less than the mammalian subacute LC_{50} value of 1330 ppm and the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm and the avian reproductive NOAEL of 25 ppm.

Postemergence Corn Spray Uses: Lorsban 4 EC may be applied in three post- emergence applications of 0.25-1.5 lbs ai/A depending on pest (i.e., at emergence, at whorl and at tassel) with a minimum application interval of 10 to 14 days. Three post-treatment scenarios are presented in the following 3 tables: a ground spray application; an aerial spray; and 3 aerial sprays at 14-day intervals.

Risk Quotients for Corn
(Postemergence/foliar, Ground Spray; 1 Applications at 1.5 lbs ai/A)
(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model)

Species	Exposure	Toxicity	Risk Quotient
Mammalian Herbivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	203 - 360 ppm	102 ppm 147 ppm 647 ppm	2.0 - 3.5 1.4 - 2.4 0.31 - 0.56
Mammalian Insectivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	23 - 203 ppm	102 ppm 147 ppm 647 ppm	0.23 - 2.0 0.16 - 1.4 0.036- 0.31
Mammalian Granivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	23 ppm	462 ppm 647 ppm 3233 ppm	0.050 0.036 0.007
Mammalian Subacute Dietary LC_{50}	23 - 360 ppm	1330 ppm	0.017- 0.27
Mammalian Reproduction NOAEL	23 - 360 ppm	10 ppm	2.3 - 36
Avian Subacute Dietary LC_{50}	23 - 360 ppm	136 ppm	0.17- 2.6
Avian Reproduction NOAEL	23 - 360 ppm	25 ppm	0.92- 14
Freshwater Fish Acute LC_{50}	5.5 ppb	1.8 ppb	3.1
Fish Reproduction NOAEC	2.7 - 4.8 ppb	0.57 ppb	4.7 - 8.4
Aquatic Invertebrate Acute LC_{50}	5.5 ppb	0.10 ppb	55
Freshwater Invert. Reproduction NOAEC	2.7 - 4.8 ppb	0.04 ppb	68 - 120
Estuarine Fish Acute LC_{50}	5.5 ppb	0.96 ppb	5.7

Estuarine Fish Reproduction NOAEC	2.7 - 4.8 ppb	0.28 ppb	9.6 - 17
Estuarine Invertebrate Acute LC_{50}	5.5 ppb	0.035 ppb	160
Estuarine Invert. Reproduction NOAEC	2.7 - 4.8 ppb	< 0.0046 ppb	> 590 > 1000
Estuarine Algae EC_{50}	5.5 ppb	140 ppb	0.039

Risk Summary for a Maximum Post-emergent Ground Spray on Corn: Chlorpyrifos sprayed postemergence at 1.5 lbs ai/A yields risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.007-3.5), subacute (0.017-0.27) and reproduction NOAEL (2.3-36), avian subacute (0.17-2.6) and reproduction NOAEL (0.92-14), freshwater fish acute (3.1) and reproduction NOAEC (4.7-8.4), aquatic invertebrate acute (55) and reproduction NOAEC (680-120), estuarine fish acute (5.7) and reproduction NOAEC (9.6-17) and estuarine invertebrate acute (160) and reproduction NOAEC (> 590 > 1000). The algal risk quotient (0.039) does not exceed any level of concern.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 11 ppm and whole fish of 7.4 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm but near the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm but less than the avian reproductive NOAEL of 25 ppm.

Risk Quotients for Corn
(Postemergence/foliar, Aerial Spray; 1 Application at 1.5 lbs ai/A)
(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model)

Species	Exposure	Toxicity	Risk Quotient
Mammalian Herbivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	203 - 360 ppm	102 ppm 147 ppm 647 ppm	2.0 - 3.5 1.4 - 2.4 0.31 - 0.56
Mammalian Insectivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	23 - 203 ppm	102 ppm 147 ppm 647 ppm	0.23 - 2.0 0.16 - 1.4 0.036- 0.31
Mammalian Granivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	23 ppm	462 ppm 647 ppm 3233 ppm	0.050 0.036 0.007
Mammalian Subacute Dietary LC_{50}	23 - 360 ppm	1330 ppm	0.017- 0.27
Mammalian Reproduction NOAEL	23 - 360 ppm	10 ppm	2.3 - 36
Avian Subacute Dietary LC_{50}	23 - 360 ppm	136 ppm	0.17 - 2.6
Avian Reproduction NOAEL	23 - 360 ppm	25 ppm	0.92- 14
Freshwater Fish Acute LC_{50}	7.7 ppb	1.8 ppb	4.3
Fish Reproduction NOAEC	3.8 - 6.8 ppb	0.57 ppb	6.7 - 12
Aquatic Invertebrate Acute LC_{50}	7.7 ppb	0.10 ppb	77
Freshwater Invert. Reproduction NOAEC	3.8 - 6.8 ppb	0.04 ppb	95 - 170

Estuarine Fish Acute LC_{50}	7.7 ppb	0.96 ppb	8.0
Estuarine Fish Reproduction NOAEC	3.8 - 6.8 ppb	0.28 ppb	14 - 24
Estuarine Invertebrate Acute LC_{50}	7.7 ppb	0.035 ppb	220
Estuarine Invert. Reproduction NOAEC	3.8 - 6.8 ppb	< 0.0046 ppb	> 830 > 1500
Estuarine Algae EC_{50}	7.7 ppb	140 ppb	0.055

Risk Summary for a Maximum Post-emergent Aerial Spray on Corn: Chlorpyrifos aerially sprayed postemergence at 1.5 lbs ai/A yields risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.007-3.5), subacute (0.017-0.27) and reproduction NOAEL (2.3-36), avian subacute (0.17-2.6) and reproduction NOAEL (0.92-14), freshwater fish acute (4.3) and reproduction NOAEC (6.7-12), aquatic invertebrate acute (77) and reproduction NOAEC (95-170), estuarine fish acute (8.0) and reproduction NOAEC (14-24) and estuarine invertebrate acute (220) and reproduction NOAEC (> 830 > 1500). The algal risk quotient (0.055) does not exceed any level of concern.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 15 ppm and whole fish of 10 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm but more than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm and less than the avian reproductive NOAEL of 25 ppm.

Multiple chlorpyrifos applications on corn are permitted by directions on registered chlorpyrifos labels. In general, label directions permit three of four applications to all types of corn. The time interval between applications is 10 to 14 days. The maximum seasonal use is 7.5 lbs ai/A in most states. In cases of multiple applications of chlorpyrifos, a half-life of 7 days has been assumed as a conservative, but not, upper limit dissipation rate presented by Racke (1993).

Risk Quotients for Corn (Emergence, Whorl, & Tassel)
(Postemergence/foliar, 3 Aerial Applications at 1.5 lbs ai/A; 14-Day Intervals)
(Terrestrial EEC's Based on FATE Model; Aquatic EECs Based on GENEEC Model)

Species	Exposure	Toxicity	Risk Quotient
Mammalian Herbivores LD_{50} (15 grams body wt.)	266 - 472 ppm	102 ppm	2.6 - 4.6
(35 grams body wt.)		147 ppm	1.8 - 3.2
(1000 grams body wt.)		647 ppm	0.41 - 0.73
Mammalian Insectivores LD_{50} (15 grams body wt.)	30 - 266 ppm	102 ppm	0.29 - 2.6
(35 grams body wt.)		147 ppm	0.20 - 1.8
(1000 grams body wt.)		647 ppm	0.046- 0.41
Mammalian Granivores LD_{50} (15 grams body wt.)	30 ppm	462 ppm	0.065
(35 grams body wt.)		647 ppm	0.046
(1000 grams body wt.)		3233 ppm	0.009
Mammalian Subacute Dietary LC_{50}	30 - 472 ppm	1330 ppm	0.023- 0.35
Mammalian Reproduction NOAEL	30 - 472 ppm	10 ppm	3.0 - 47

Avian Subacute Dietary LC_{50}	30 - 472 ppm	136 ppm	0.22 - 3.5
Avian Reproduction NOAEL	30 - 472 ppm	25 ppm	1.2 - 19
Freshwater Fish Acute LC_{50}	24 ppb	1.8 ppb	13
Fish Reproduction NOAEC	11.7 -21.5 ppb	0.57 ppb	21 - 38
Aquatic Invertebrate Acute LC_{50}	24 ppb	0.10 ppb	240
Freshwater Invert. Reproduction NOAEC	11.7 -21.5 ppb	0.04 ppb	290 - 540
Estuarine Fish Acute LC_{50}	24 ppb	0.96 ppb	25
Estuarine Fish Reproduction NOAEC	11.7 -21.5 ppb	0.28 ppb	42 - 77
Estuarine Invertebrate Acute LC_{50}	24 ppb	0.035 ppb	690
Estuarine Invert. Reproduction NOAEC	11.7 -21.5 ppb	< 0.0046 ppb	>2500 > 4700
Estuarine Algae EC_{50}	24 ppb	140 ppb	0.17

Risk Summary for Three Maximum, Post-emergent Aerial Spray Treatments on Corn: Chlorpyrifos aerially sprayed postemergence at 1.5 lbs ai/A yields risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.009-4.6), subacute (0.023-0.35) and reproduction NOAEL (3.0-47), avian subacute (0.22-3.5) and reproduction NOAEL (1.2-19), freshwater fish acute (13) and reproduction NOAEC (21-38), aquatic invertebrate acute (240) and reproduction NOAEC (290-540), estuarine fish acute (25) and reproduction NOAEC (42-77) and estuarine invertebrate acute (690) and reproduction NOAEC (> 2500 > 4700). The algal risk quotient (0.17) does not exceed any level of concern.

Food Chain Effect: Piscivorous mammals are exposed to estimated residues in the fish viscera of 46 ppm and whole fish of 32 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm but more than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm, but more than the avian reproductive NOAEL of 25 ppm.

In the case of sweet corn in Florida and Georgia, the label permits retreatment as necessary, but do not apply more than 11 lbs ai/A (11 times at 1 lb ai/A or 22 times at 0.5 lb ai/A). The typical time interval between treatments is reported to be 3 days (Personal communication: Georgia Agricultural Extension Agent). Aquatic EECs were modelled by EFED using the PRZM3.12-EXAMS model on Tifton loamy sand soil in Crisp Co., Georgia and local rainfall conditions. The following table assesses risks posed by 11 applications at 1 lb ai/A.

Risk Quotients for Corn in Crisp Co., Georgia (Foliar Spray, 11 Aerial Applications at 1 lbs ai/A; 3-Day Interval) (Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on PRZM3.12-EXAMS Model)			
Species	**Exposure**	**Toxicity**	**Risk Quotient**

Mammalian Herbivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	505 - 898 ppm	102 ppm 147 ppm 647 ppm	5.0 - 8.8 3.4 - 6.1 0.78 - 1.4
Mammalian Insectivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	56 - 505 ppm	102 ppm 147 ppm 647 ppm	0.55 - 5.0 0.38 - 3.4 0.087- 0.78
Mammalian Granivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	56 - 505 ppm	462 ppm 647 ppm 3233 ppm	0.12 0.087 0.017
Mammalian Subacute Dietary LC_{50}	56 - 898 ppm	1330 ppm	0.042- 0.68
Mammalian Reproduction NOAEL	56 - 898 ppm	10 ppm	5.6 - 90
Avian Subacute Dietary LC_{50}	56 - 898 ppm	136 ppm	0.41 - 6.6
Avian Reproduction NOAEL	56 - 898 ppm	25 ppm	2.2 - 36
Freshwater Fish Acute LC_{50}	33.8 ppb	1.8 ppb	19
Fish Reproduction NOAEC	23.7 - 28.1 ppb	0.57 ppb	42 - 49
Aquatic Invertebrate Acute LC_{50}	33.8 ppb	0.10 ppb	340
Freshwater Invert. Reproduction NOAEC	23.7 - 28.1 ppb	0.04 ppb	590 - 700
Estuarine Fish Acute LC_{50}	33.8 ppb	0.96 ppb	35
Estuarine Fish Reproduction NOAEC	23.7 - 28.1 ppb	0.28 ppb	85 - 100
Estuarine Invertebrate Acute LC_{50}	33.8 ppb	0.035 ppb	970
Estuarine Invert. Reproduction NOAEC	23.7 - 28.1 ppb	< 0.0046 ppb	> 5200 > 6100
Estuarine Algae EC_{50}	33.8 ppb	140 ppb	0.24

Risk Summary for Eleven Maximum, Post-emergent Aerial Spray Applications on Corn: Chlorpyrifos aerially sprayed postemergence 11 times at 1.0 lb ai/A yields risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.017-8.8), subacute (0.042-0.68) and reproduction NOAEL (5.6-90), avian subacute (0.41-6.6) and reproduction NOAEL (2.2-36), freshwater fish acute (19) and reproduction NOAEC (42-49), aquatic invertebrate acute (340) and reproduction NOAEC (590-700), estuarine fish acute (35) and reproduction (85-100) NOAEC and estuarine invertebrate acute (970) and reproduction NOAEC (> 5200 > 6100). The algal risk quotient (0.24) does not exceed any level of concern.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 92 ppm and whole fish of 65 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm but more than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm but more than the avian reproductive NOAEL of 25 ppm.

Risk Summary for Maximum Spray Applications to Corn: Assessment of chlorpyrifos spray treatments to corn at pre-plant, emergence, whorl, tassel stages, and 11 weekly applications

indicate high risks to many non-target aquatic and terrestrial animals in the above five treatment scenarios. Comparison of terrestrial risk quotients for the five spray treatment scenarios indicate wildlife risks in descending order: (3 lbs ai/A incorporated > 11 weekly applications at 1 lb ai/A and 3 biweekly applications at 1.5 lbs ai/A > ground and aerial applications at 1.5 lbs ai/A. Risk differences between the 5 treatments are 2 fold or less. Terrestrial risk quotients are actually lower for 11 applications at 1 lb ai/A than for 1 application of 3 lbs ai/A, because the 7-day half-life on vegetation results in maximum residues at twice the application rate. Risk quotients exceed the high risk LOCs for all wildlife categories, except mammalian granivores weighing 1,000 grams.

Aquatic risk quotients for the 5 treatment scenarios in descending order are 11 applications at 1 lb ai/A > 3 applications at 1.5 lbs ai/A > 1 aerial application at 1.5 lbs ai/A > 3 lbs ai/A soil incorporated > a ground application at 1.5 lbs ai/A. Risk differences between treatments are 12 fold or less. Risk quotients for a ground treatment at 1.5 lbs ai/A is about 28 percent lower than for an aerial applications at the same use rate. Risk quotients exceed high risk LOCs for all aquatic categories and in some cases, corn applications of chlorpyrifos pose potential risks via food chain effects to piscivorous mammals and birds.

The range of risk quotients for the five spray application methods assessed are as follows: mammalian herbivore acute (0.96-7.1), mammalian insectivore acute (0.11-4.0), mammalian granivore acute (0.007-0.88), mammalian subacute dietary (0.15-0.54), mammalian chronic (20-72), avian subacute dietary (1.5-5.3), avian chronic (8.1-29), freshwater fish acute (3.1-36) and chronic (4.7-89), aquatic invertebrate acute (55-650) and chronic (68-1300), estuarine fish acute (5.7-68) and chronic (9.6-180), estuarine invertebrate acute (160-1900) and chronic (>590->11,000), piscivorous mammalian dietary (0.006-0.074) and chronic (0.74-9.8), and piscivorous avian dietary (0.054-0.72) and chronic (0.30-3.9).

Comparison of risk quotients for the 5 different applications indicates that the ground application has the lowest risks. Risk quotients for aquatic species from a ground application are about 28 percent lower than for a single aerial application at the same application rate. In all cases, applications of Lorsban 4 EC to corn poses acute and chronic risks to aquatic and terrestrial non-target organisms for all classes. If runoff occurs into shallower aquatic habitats than a 2-meter deep pond, aquatic exposure levels will increase, as will risk quotients. In the case of 3-foot standing waters and 6-inch marshes and swamps, the aquatic exposures and risk quotients will be slightly greater than for the 2-meter pond.

Corn Field Study with Spray Applications: Field studies were conducted in Iowa assessing risks of Lorsban 4 EC applications to corn with multiple applications. In general, the measured chlorpyrifos residue levels reported in the sprayed corn field study support the EECs used in this risk assessment. Chlorpyrifos levels found in the corn field study are compared to predicted EECs used in this risk assessment in the table below for spray treatments.

In the field study, chlorpyrifos was sprayed as Lorsban 4 EC, an emulsifiable concentrate formulation, to 4 fields (4 applications per field at 3, 1.5, 1.5, and 1.5 lbs ai/A each). Chlorpyrifos

levels were measured in various environmental samples. Soils were sampled to a depth of 2.5 cm.

CHLORPYRIFOS 4E APPLIED 4 TIMES TO CORN PREPLANT AT 3.0 LBS AI/A (SOIL INCORPORATED TO UNSPECIFIED DEPTH) AND THREE TIMES AT 1.5 LBS AI/A (EMERGENCE, WHORL, & TASSEL)				
Substrate (1, 2, 3 & 4 Appls.)	Initial Mean Conc.	Initial Mean Ranges	Highest Conc.	EFED Initial EEC
1st Soil (2.5 cm)	5.53 ppm	3.21-9.11 ppm	14.8[a] ppm	6.6 ppm
2nd Soil (2.5 cm)	5.66 ppm	3.20-7.41 ppm	9.45 ppm	3.3 ppm
3rd Soil (2.5 cm)	4.15 ppm	2.99-5.27 ppm	8.37 ppm	N/A
4th Soil (2.5 cm)	2.00 ppm	1.11-4.41 ppm	8.38 ppm	N/A
1st Crop Foliage	N/A	N/A	N/A	N/A
2nd Crop Foliage	358 ppm	151-492 ppm	544 ppm	203 ppm
3rd Crop Foliage	193 ppm	149-288 ppm	418 ppm	N/A
4th Crop Foliage	104 ppm	39-166 ppm	257 ppm	266 ppm
1st Noncrop Foliage	2.70 ppm	n.d.-5.66 ppm	10.9 ppm	20 ppm
2nd Noncrop Foliage	1.87 ppm	n.d.-5.81 ppm	9.83 ppm	10.1 ppm
3rd Noncrop Foliage	29.6 ppm	10.5-59.5 ppm	129 ppm	15.2 ppm
4th Noncrop Foliage	33.8 ppm	0.68-92.9 ppm	173 ppm	17.7 ppm
1st Invertebrates	n.d.	n.d.	n.d.	45 ppm
2nd Invertebrates	0.82 ppm	n.d.-0.88 ppm	11.5[b] ppm	15.2[c] ppm
3rd Invertebrates	no data	N/A	N/A	33.9 ppm
4th Invertebrates	n.d.	n.d.	7.33[d] ppm	19.4[e] ppm
1st Water (ppb)	2.85 ppb	2.55-3.00 ppb	6.32[f] ppb	8.7-11[i] ppb
2nd Water (ppb)	66.9 ppb	n.d.-97.6 ppb	115 ppb	6.8- 7.7[j] ppb
3rd Water (ppb)	no data	no data	no data	N/A
4th Water (ppb)	n.d.[g]	n.d.	2.20[h] ppb	21.5-24[k] ppb

[a] Highest concentrations were found in soil at later times (i.e., 16.7 ppm on Day 4, and 22.8 ppm on Day 7)
[b] Highest concentration was found in field invertebrates on Day 4 (11.5 ppm)
[c] Concentration estimated for Day 4 after the first application

[d] Highest concentration was found in field invertebrates on Day 7 (7.33 ppm)
[e] Concentration estimated for Day 7 after the third application
[f] Highest concentration was found on Day 14 (6.32 ppb)
[g] n.d. -- concentration is below the level of quantification (1.0 ppb)
[h] Highest concentration was found on Day 7
[i] Aquatic EECs are for 96-hours and peak conc. for ground spray (PRZM3-EXAMS)
[j] Aquatic EECs are for 96-hours and peak concentrations for one aerial spray application (GENEEC Model)
[k] Aquatic EECs are for 96-hours and peak concentration for three aerial spray applications (GENEEC Model)

Estimated terrestrial EECs used in the corn risk assessment generally occur in the range of the measured chlorpyrifos levels reported in the Iowa, corn field study. Initial, mean measured soil concentrations which ranged from 1.11 to 9.11 ppm span the EECs of 3.3 and 6.6 ppm that are estimated with the soil dilution nomograph for soils when corrected for soil cores 2.5 cm deep. Chlorpyrifos concentrations in soil were not used in this risk assessment. Maximum, initial measured chlorpyrifos levels on crop foliage ranged from 257 ppm to 544 ppm equal or exceed residue levels of 203 and 266 ppm predicted on foliage by values in Fletcher *et al*. (1994). Maximum, initial measured chlorpyrifos levels on adjacent non-crop foliage ranged from 9.83 to 173 ppm are half, equal to, or exceed predicted levels of 10.1 to 17.7 ppm. Invertebrate species analyzed for chlorpyrifos were not identified, hence it is unclear whether they were sprayed directly or may have been covered by soil or migrated into the treated area after the application. Comparison of measured chlorpyrifos levels on invertebrates were within 1.3 to 2.7 fold of predicted levels for the same post-treatment periods.

Comparison of mean measured, aquatic concentrations (n.d. to 97.6 ppb) to estimated aquatic EECs (6.8 to 24 ppb) generally 3 to 5 times lower than the predicted EECs, but in one case, the mean measured level (115 ppb) was 15 times more than the predicted EEC. Mean measured water concentrations frequently exceed the acute fish LC_{50} and acute aquatic invertebrate EC_{50} values for sensitive species.

In the same manner that the Iowa corn field study support EECs, terrestrial risk quotients for spray treatments on corn are supported by carcasses testing positive for chlorpyrifos and animals showing cholinesterase behavior. Twenty-seven carcasses were found including 13 birds, 9 small mammals, 4 reptiles and 1 amphibian. Only four carcasses were analyzed for chlorpyrifos; a robin which showed cholinesterase behavior was caught and died and a field mouse; both tested positive for chlorpyrifos, a vole and a shrew tested negative. A second robin showing cholinesterase behavior was also caught and survived, but it is counted as affected by chlorpyrifos.

Granular Preplant Broadcast, Soil Incorporated Corn Use: The typical granular formulation used on corn is Lorsban 15G (15% active ingredient). Directions for use on corn on registered labels allow chlorpyrifos application at 1 to 2 lbs ai/A evenly distributed over the treated area and incorporated into the soil using an S tine, C tine, disc cultivator, or other suitable incorporation equipment set to cut to a depth of 4 to 6 inches. It is assumed that only 15 percent of the granules are available to wildlife following soil incorporation. The risk quotients for mammalian herbivores, insectivores, and granivores are combined, because the number of granules per ft^2 available to all mammals is equal. Risk quotients for granular pre-plant use on corn are assessed in the following table.

Granular Risk Quotients for Corn (Pre-Plant, Ground Broadcast; 1 Application at 2 lbs ai/A; 4-inch Soil Incorporation) (Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on GENEEC Model)				
Species	**Toxicity**	**Exposure**	**Toxicity Dose**	**Risk Quotient**
Mammalian Acute LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	97 mg/kg	3.1 mg/ft^2*	1.5 mg 3.4 mg 97 mg	2.1 0.91 0.032
Avian Acute Oral LD_{50} (27.7 grams body wt.)	10 mg/kg	3.1 mg/ft^2*	0.28 mg	11
Freshwater Fish Acute LC_{50}	1.8 ppb	1.66 ppb		0.92
Fish Reproduction NOAEC	0.57 ppb	0.81 -1.44 ppb		1.4 - 2.5
Aquatic Invertebrate Acute LC_{50}	0.10 ppb	1.66 ppb		17
Freshwater Invert. Reproduction NOAEC	0.04 ppb	0.81 -1.44 ppb		20 - 36
Estuarine Fish Acute LC_{50}	0.96 ppb	1.66 ppb		1.7
Estuarine Fish Reproduction NOAEC	0.28 ppb	0.81 -1.44 ppb		2.9 - 5.1
Estuarine Invertebrate Acute LC_{50}	0.035 ppb	1.66 ppb		47
Estuarine Invert. Reproduction NOAEC	< 0.0046 ppb	0.81 -1.44 ppb		>180 - >310
Estuarine Algae EC_{50}	140 ppb	1.66 ppb		0.012

$$* \text{ mg ai/foot}^2 = \frac{2 \text{ lb ai/A} \times 453{,}590 \text{ mg/lb} \times 15\% \text{ exp.}}{43{,}560 \text{ ft}^2\text{/A}} = 3.1 \text{ mg/ft}^2$$

Risk Summary for Pre-plant Granular Broadcast Applications at 2 lbs ai/A on Corn: Chlorpyrifos granules broadcast at pre-plant at 2 lbs ai/A and soil incorporated to a depth of 4-inches yield risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.032-2.1), avian acute (11), freshwater fish acute (0.92) and reproduction NOAEC (1.4-2.5), aquatic invertebrate acute (17) and reproduction NOAEC (20-36), estuarine fish acute (1.7) and reproduction NOAEC (2.9-5.1) and estuarine invertebrate acute (47) and reproduction NOAEC (> 180 > 310). The algal risk quotient (0.012) does not exceed any level of concern.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 3.2 ppm and whole fish of 2.2 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm and less than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm and less than the avian reproductive NOAEL of 25 ppm.

At-Plant Granular Band Corn Uses: Lorsban 15 G may be applied at 1.2 oz. ai./1,000 feet of row (band, T-band or in-furrow) and at 1.8 oz. ai./1,000 feet of row in case of severe infestations. In conventional, minimum and no-till corn, the granules are placed in a 6 or 7-inch wide band over the row behind the planter shoe, in front of the press wheel, and then incorporated into the top 1

or 2 inches of soil using tines or chains or other suitable equipment. For T-band treatments, granules are applied over an open seed furrow and in conventional and minimum-till corn, granules are incorporated into the top 0.5-1 inch of soil using suitable equipment. For in-furrow treatment, granules are directed into the planter shoe with the seed or place the applicator tube directly behind the planter shoe so that the granules drop into the seed furrow or the granular band applicator is placed behind the planter shoe so that the granules fall on the soil surface and into the open seed furrow and are covered with soil. From this description it is assumed that 15 to 100 percent of the granules are available to wildlife from band treatment with press wheel (unincorporated) and T-band (unincorporated) and 1 percent are available from in-furrow treatment. Band width should be 0.5 ft as worst case, but 0.6 ft was used to conform to the corn cluster analysis.

Row spacing for all corn crops are assumed to be 30 inches. Band widths for corn are 6 to 7 inches and 7 to 10 inches. Risks to wildlife are considered to be greatest when a given application rate is applied in a narrower band width (more concentrated); the narrowest band width is assumed, if it is not given. In the case of corn, a 7-inch band width was used to replicate the same risk assessment assumptions as in the corn cluster.

When application rates are expressed as ounces/1000 feet of row, the application rate in lbs ai/A must be determined in order to calculated the aquatic EEC's with the GENEEC model. The following formula can be used to calculate lbs ai/A from banded applications expressed as oz. ai/1000 feet of row, because with the exception of runoff reductions for soil incorporation, there is no reason to suspect that aquatic EEC's are affected differently by banded treatments compared to even distribution over the field.

In order to calculate aquatic EECs, oz. ai/1000 feet of row must be converted into lbs ai/A. The formula below makes that conversion.

$$\text{lbs ai/A} = \frac{1.8\ (\text{oz. ai/1000 feet of row}) \times 43560\ \text{ft}^2/\text{A}}{16\ \text{oz./lb} \times 1000\ \text{ft} \times 2.5\ \text{row spacing (ft.)}} = 2\ \text{lbs ai/A}$$

In the corn cluster, an at-plant scenario with a banded treatment with Lorsban 15 G applied at 1.5 lbs ai/A was assessed for risks. The granules are placed in a 6- or 7-inch wide band over the row behind the planter shoe, in front of the press wheel, and incorporated into the top 1-inch of soil using tines or chains or other suitable equipment. For consistency with the corn cluster assessment, a 7-inch wide band was used in this assessment. The 6-inch wide band would yield slightly higher terrestrial risk quotients than for 7-inch wide bands, because the granules are more dense as computed for the LD_{50}s per square foot risk assessment. Risk quotients are assessed in the following table.

Granular Risk Quotients for Corn
(At-Plant, 7-inch Band or T-Band; 1 Application at 1.8 oz./1,000 Feet of Row; 1-inch Soil Incorporation)
(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on Formula and GENEEC Model)**

Species	Toxicity	Exposure	Toxicity Dose	Risk Quotient
Mammalian Acute LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	97 mg/kg	12.8 mg/ft^2*	1.5 mg 3.4 mg 97 mg	8.5 3.8 0.13
Avian Acute Oral LD_{50} (27.7 grams body wt.)	10 mg/kg	12.8 mg/ft^2*	0.28 mg	46
Freshwater Fish Acute LC_{50}	1.8 ppb	6.64 ppb		3.7
Fish Reproduction NOAEC	0.57 ppb	3.36-5.78 ppb		5.9 - 10
Aquatic Invertebrate Acute LC_{50}	0.10 ppb	6.64 ppb		66
Freshwater Invert. Reproduction NOAEC	0.04 ppb	3.36-5.78 ppb		84 - 140
Estuarine Fish Acute LC_{50}	0.96 ppb	6.64 ppb		6.9
Estuarine Fish Reproduction NOAEC	0.28 ppb	3.36-5.78 ppb		12 - 21
Estuarine Invertebrate Acute LC_{50}	0.035 ppb	6.64 ppb		190
Estuarine Invert. Reproduction NOAEC	< 0.0046 ppb	3.36-5.78 ppb		>730 > 1300
Estuarine Algae EC_{50}	140 ppb	6.64 ppb		0.047

* mg ai/ft^2 = $\frac{\text{(1.8 oz ai/1000 ft row) X 28,349 mg/oz. X 15\% exposed}}{\text{1,000 feet row X band width (0.6 ft.)}}$ = 12.8 mg ai/ft^2

** lbs ai/A = $\frac{\text{1.8 (oz. ai./1000 feet of row) X 43560 ft}^2\text{/A}}{\text{16 oz./lb X 1000 ft X 2.5 row spacing (ft.)}}$ = 2 lbs ai/A

Risk Summary for Maximum At-plant, Granular Banded Corn Use: Chlorpyrifos granules applied in a banded treatment at-plant at 1.8 oz. ai per 1,000 foot row and soil incorporated to a depth of 1 inch yield risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.13-8.5), avian acute (46), freshwater fish acute (3.7) and reproduction NOAEC (5.9-10), aquatic invertebrate acute (66) and reproduction NOAEC (84-140), estuarine fish acute (6.9) and reproduction NOAEC (12-21) and estuarine invertebrate acute (190) and reproduction NOAEC (> 730 > 1300), and estuarine algae (0.047).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 13 ppm and whole fish of 9.3 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm but more than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm and less than the avian reproductive NOAEL of 25 ppm.

Postplant Corn Uses: Three types of postplant corn treatments are cited on the Lorsban 15 G label. At cultivation, granules may be placed at the base of the plant on both sides of the row just ahead of the cultivation shovels and "cover the soil" at 0.9-1.2 oz. ai/1000 feet of row. Or granules at 0.75-0.975 lbs ai/A may be uniformly broadcast granules over the corn plants by aerial application at whorl and tassel stages or placed into the corn whorls by ground application. Risk

quotients for the banded treatment is addressed in the above table, but the risk quotients are one-half the values in the table due to the lower application rate. The table below calculates risk quotients for two broadcast applications (i.e., whorl and tassel treatments). For the LD_{50} per ft^2 assessment, it is assumed that 50% of the granules at intercepted by plant surfaces (50% reach the ground) and that no granules are left 2 weeks after the previous applications.

Granular Risk Quotients for Corn
(Postemergence Broadcast, 2 Applications at 0.975 ai/A; 14-Day Interval; 50% Interception by plant)
(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on GENEEC Model)

Species	Toxicity	Exposure	Toxicity Dose	Risk Quotient
Mammalian Acute LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	97 mg/kg	5 mg/ft^2*	1.5 mg 3.4 mg 97 mg	3.3 1.5 0.05
Avian Acute Oral LD_{50} (27.7 grams body wt.)	10 mg/kg	5 mg/ft^2*	0.28 mg	18
Freshwater Fish Acute LC_{50}	1.8 ppb	6.35 ppb		3.5
Fish Reproduction NOAEC	0.57 ppb	3.1- 5.5 ppb		5.4 - 9.6
Aquatic Invertebrate Acute LC_{50}	0.10 ppb	6.35 ppb		64
Freshwater Invert. Reproduction NOAEC	0.04 ppb	3.1- 5.5 ppb		78 - 140
Estuarine Fish Acute LC_{50}	0.96 ppb	6.35 ppb		6.6
Estuarine Fish Reproduction NOAEC	0.28 ppb	3.1- 5.5 ppb		11 - 20
Estuarine Invertebrate Acute LC_{50}	0.035 ppb	6.35 ppb		180
Estuarine Invert. Reproduction NOAEC	< 0.0046 ppb	3.1- 5.5 ppb		>670 > 1200
Estuarine Algae EC_{50}	140 ppb	6.35 ppb		0.045

* mg ai/$foot^2$ = $\frac{0.975 \text{ lb ai/A X } 453{,}590 \text{ mg/lb}}{43{,}560 \text{ ft}^2\text{/A}}$ = 10.15 mg/ft^2 / 2 (50% plant interception) = 5 mg/ft^2

Risk Summary for Two Maximum Postemergence, Granular Aerial Applications on Corn: Chlorpyrifos granules aerially applied to foliar corn at 0.975 lbs ai/A yield risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.05-3.3), avian acute (18), freshwater fish acute (3.5) and reproduction NOAEC (5.4-9.6), aquatic invertebrate acute (64) and reproduction NOAEC (78-140), estuarine fish acute (6.6) and reproduction NOAEC (11-20) and estuarine invertebrate acute (180) and reproduction NOAEC (> 670 > 1200). The algal risk quotient (0.045) does not exceed any level of concern.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 17 ppm and whole fish of 12 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm but more than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm and less than the avian reproductive NOAEL of 25 ppm.

Risk Summary for Maximum Granular Applications to Corn: Assessment of chlorpyrifos granular treatments to corn at pre-plant, at plant, at cultivation, whorl, and tassel stages, indicate high risks to many species from all five treatment scenarios. Comparison of terrestrial risk quotients for the five granular treatment scenarios indicate wildlife risks in descending order: (at-plant at 1.8 oz./1,000 feet incorporated > whorl and tassel aerial applications at 0.975 lbs ai/A > at cultivation at 1.2 oz./1,000 feet incorporated > pre-plant at 2 lbs ai/A incorporated. Risk differences between the 5 treatments are about 5 fold or less. Risk quotients exceed the high risk LOCs for all wildlife categories, except mammals weighing 1,000 grams.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 12 ppm and whole fish of 8.5 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm but more than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm and less than the avian reproductive NOAEL of 25 ppm.

Aquatic risk quotients for the 5 treatments in descending order are the same as for terrestrial species. Risk differences between treatments are also about 5 fold or less. Risk quotients exceed high risk LOCs for all aquatic categories, except for piscivorous categories.

The range of risk quotients for the five granular application methods assessed are as follows: mammalian acute (0.032-11), avian acute (11-61), freshwater fish acute (0.9-4.8) and chronic (1.4-13), aquatic invertebrate acute (17-86) and chronic (20-190), estuarine fish acute (1.7-9.0) and chronic (2.9-27), estuarine invertebrate acute (47-250) and chronic (>176->1,600). Except for the pre-plant, soil incorporated uses, the acute LC50 values for both fish and invertebrate species were exceeded for over 56 days by the EEC predicted for granular applications on corn.

Food Chain Effects: Estimates of chlorpyrifos residue levels in fish viscera range 3.2 to 98 ppm and residues in whole fish range from 2.2 to 68 ppm. These residues levels are less than the mammalian subacute LC_{50} value of 1330 ppm but only one value is less than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm but two of the five uses are more than the avian reproductive NOAEL of 25 ppm.

In all cases, applications of Lorsban 15G to corn poses acute risks to small mammals and birds, and acute and chronic risks to aquatic non-target organisms for all categories, and in some cases there are risks to piscivorous mammals and birds. Seventeen carcasses were collected from corn fields treated with Lorsban 15G in a Iowa terrestrial field studies including 9 birds, 7 mammals, and i amphibian. Only 3 out of the 17 carcasses were analyzed for chlorpyrifos. One shrew tested positive for chlorpyrifos. Another shrew and a rabbit showed behavior indicative of cholinesterase inhibition.

Corn Field Study with 15% Granular Applications: Granular chlorpyrifos residue levels measured in an Iowa, corn field study are comparable to the predicted EECs in the following table

using the same EEC methodology as in the risk assessment tables above. In the field study, chlorpyrifos was applied as Lorsban 15 G, a granular formulation, to 4 fields (3 applications per field; 1.1 to 2.9 kg/ha [1 - 2.6 lbs ai/A]). Soils were sampled to a depth of 2.5 cm.

CHLORPYRIFOS 15G APPLIED THREE TIMES TO CORN AT-PLANT AT 2.6 LBS AI/A (SOIL INCORPORATED BY PRESS WHEEL) AND TWO APPLICATIONS AT 0.975 LBS AI/A (AT WHORL & TASSEL)				
Substrate (1, 2 & 3 Appls.)	Initial Mean Conc.	Initial Mean Ranges	Highest Conc.	EFED Initial EEC
1st Soil (25 cm)	22.4 ppm	9.06-42.2 ppm	95.6[a] ppm	5.72 ppm
2nd Soil (25 cm)	2.87 ppm	0.16-5.18 ppm	14.5[b] ppm	2.2 ppm
3rd Soil (25 cm)	6.36 ppm	3.17-11.9 ppm	30.6 ppm	4.4 ppm
1st Invertebrates	n.d.	n.d.	n.d.	N/A
2nd Invertebrates	no data	no data	no data	no data
3rd Invertebrates	4.95 ppm	3.70-5.79 ppm	7.83[c] ppm	N/A
1st Water (ppb)	n.d.	n.d.	n.d.	7.4-8.6[d] ppb
2nd Water (ppb)	no data	no data	no data	2.8-3.2[e] ppb
3rd Water (ppb)	n.d.	n.d.-1.46[f] ppb	1.80[f] ppb	5.5-6.35[e] ppb

[a] Several samples taken on Day 7 were higher than any soil conc. on Day 0
[b] Highest conc. found on Day 4 and mean conc. was higher 5.61 versus 2.87 ppm
[c] Highest conc. found on Day 7 and mean conc. was higher 4.95 versus 2.02 ppm
[d] Aquatic EECs are for 96-hours and peak concentrations for broadcast (although a press wheel may reduce runoff by firming the soil, it does not constitute soil incorporation)
[e] Aquatic EECs are for 96-hours and peak concentrations for broadcast
[f] Measurable levels in water were found only on Day 7; fewer samples were collected on all other sampling days

Terrestrial samples measured in the corn granular field study do not correspond to the exposure method used for granular risk assessment (i.e., mg per square foot). Mean measured chlorpyrifos levels in soil (i.e., 0.16 to 42.2 ppm) bracket the predicted EECs (2.2 to 5.72 ppm) based on the soil dilution nomograph. While soil organisms may be contaminated by pesticides, the agency lacks a methodology to predict EECs for invertebrates exposed to granular pesticides.

Comparison of mean measured, aquatic concentrations (n.d. to 1.46 ppb) to estimated aquatic EECs (6.8 to 24 ppb) generally 3 to 5 times lower than the predicted EECs. Two out of three measured water concentrations equal the acute fish LC_{50} and all three samples exceed acute aquatic invertebrate EC_{50} values for sensitive species.

Again, field study results support both the EECs and risk quotients for corn treated with Lorsban

15 G treatments. Seventeen carcasses were found on the granular-treated fields. Only four carcasses were analyzed for chlorpyrifos. A brown thrush, which was hit by a car, was analyzed and found negative for chlorpyrifos. The carcass of a field mouse, *Peromyscus* sp. contained 0.7 ppm. A short-tailed shrew contained 2.1 ppm in its internal tissues; a second shrew exhibited behaviors typical of cholinesterase inhibition; both were considered positive for chlorpyrifos effects. An eastern cottontail rabbit was found slightly affected (i.e., showing behavior indicating cholinesterase inhibition). While the rabbit could not be caught, it was considered to show positive effects for chlorpyrifos. An American toad was analyzed, but it contained no chlorpyrifos. Four out of six animals evaluated, 67 percent, either tested positive for chlorpyrifos or showed behavior indicative of cholinesterase inhibition.

Carcass detectability tests showed that searchers might be expected to find few casualties compared to the number of animals killed. The highest combined recovery rates generally decreased as the crop grew large (i.e., 14.3 % preplant and at-plant, 26.1 % at emergence, 13.8 % at whorl, and 8.7% at tassel). Recovery levels in the three search areas were generally higher for the interior, then field perimeter, and lowest in adjacent habitats. Preplant and at-plant recovery rates were 18.3 % in the interior, 18.3 % perimeter, and 3.6 % adjacent. Recovery rates at emergence were 26.1% in the interior, 41.5 % perimeter, and 8.0 % in adjacent areas. Recovery rates at whorl were 17.5 % in the interior and slightly less in the perimeter and adjacent areas. At the tassel stage, all recovery rates were similar for all areas (8.7 %).

Comparison of Maximum Risk Quotients for Corn Formulations: Comparison of terrestrial risks for liquid and granular formulations is difficult, because the exposures are different and risks are expressed in different units. Assuming that the lower granular application rates for each growth stage represent equal efficacy as the respective spray treatments, the risk comparisons are as follows. Preplant risk quotients for granular use are 2 to 3.5 fold lower than sprays for mammals; 20 to 36 fold higher than sprays for birds; and 4.3 lower than sprays for aquatic organisms. At plant risk quotients for granular use are 3.1 to 5.5 fold higher than spray use for mammals; 23 to 41 fold higher for birds; and 3.1 fold lower for aquatic organisms. Whorl and tassel risk quotients for granular use are similar to spray treatment for small mammals; 14 to 24 fold higher for birds; and 2.4 fold less for aquatic organisms.

A comparison of risk quotients for granular and spray uses are about equal for small mammals; consistently higher with granules for birds; and about equal or less with granules for aquatic organisms.

The most important factor affecting terrestrial risks is the application rate and the amount available on the substrate surface. That is, risks to terrestrial species are more affected by high application rates than multiple applications. For example, residue levels on short grass after 1 application at 3 lbs ai/A is 720 ppm compared to 480 ppm for 11 applications at 1 lb ai/A. The reason is the relatively short half-life of 7-days on vegetation and the 7-day interval between treatments.

Risk quotients for aquatic species are lower for ground applications compared to aerial uses. Risk

quotients for aquatic species for all application methods exceed levels of concern and LC_{50} values for all aquatic categories, except piscivorous mammals and birds. Acute risk quotients are as high as 36 and 68 for the fish, 650 to 1900 for aquatic invertebrates, 0.05 to 0.07 for mammalian piscivores, and 0.5 to 0.7 for avian piscivores. Reproductive risk quotients are as high as 89 to 180 for fish, 1300 to 11,000 for invertebrates, and 4.9 and 3.9 for piscivorous mammals and birds, respectively. The highest aquatic risks occurred from 11 applications at 1 lb ai/A. The most important factor in aquatic exposures are the total amount applied, irrespective of the number of applications.

Typical Corn Use: According to BEAD, the typical use rate on corn is a single preplant, granular application at an average of 1.1 lbs ai/A. Following the broadcast application, the granules are incorporated into the soil. It is assumed that only 15 percent of the granules are available to wildlife. In the corn cluster, risk quotients for granular uses on corn were assessed for two states, Iowa and Mississippi and are included here to provide a sense of variability in the aquatic risks in different regions of the country. Aquatic EECs were modelled by EFED using the PRZM3.12-EXAMS model on Marshall silty clay loam soil in Pottawattamie Co., Iowa and local rainfall conditions. Risk quotients for granular use on corn in these two states are assessed in the following two tables.

Granular Risk Quotients for Corn in Pottawattamie Co., Iowa
(Pre-Plant, Ground Broadcast; 1 Application at 1.1 lbs ai/A; 4-inch Soil Incorporation)
(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on PRZM3.12-EXAMS Model)

Species	Toxicity	Exposure	Toxicity Dose	Risk Quotient
Mammalian Acute LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	97 mg/kg	1.7 mg/ft^2*	1.5 mg 3.4 mg 97 mg	1.1 0.50 0.018
Avian Acute Oral LD_{50} (27.7 grams body wt.)	10 mg/kg	1.7 mg/ft^2*	0.28 mg	6.1
Freshwater Fish Acute LC_{50}	1.8 ppb	0.98 ppb		0.54
Fish Reproduction NOAEC	0.57 ppb	0.44 - 0.77 ppb		0.77 - 1.4
Aquatic Invertebrate Acute LC_{50}	0.10 ppb	0.98 ppb		9.8
Freshwater Invert. Reproduction NOAEC	0.04 ppb	0.44 - 0.77 ppb		11 - 19
Estuarine Fish Acute LC_{50}	0.96 ppb	0.98 ppb		1.0
Estuarine Fish Reproduction NOAEC	0.28 ppb	0.44 - 0.77 ppb		1.6 - 2.8
Estuarine Invertebrate Acute LC_{50}	0.035 ppb	0.98 ppb		28
Estuarine Invert. Reproduction NOAEC	< 0.0046 ppb	0.44 - 0.77 ppb		> 95 > 167
Estuarine Algae EC_{50}	140 ppb	0.98 ppb		0.007

* mg ai/foot^2 = $\frac{1.1 \text{ lb ai/A} \times 453{,}590 \text{ mg/lb} \times 15\% \text{ exp.}}{43{,}560 \text{ ft}^2\text{/A}}$ = 1.7 mg/ft^2

Risk Summary for a Granular Broadcast Application on Corn in Iowa: Chlorpyrifos granules broadcast at pre-plant at 1.1 lbs ai/A and soil incorporated to a depth of 4-inches yield risk quotients which exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.018-1.1), avian acute (6.1), freshwater fish acute (0.54) and reproduction NOAEL (0.77-1.4), aquatic invertebrate acute (9.8) and reproduction NOAEL (11-19), estuarine fish acute (1.0) and reproduction (1.6-2.8) and estuarine invertebrate acute (28) and reproduction NOAEL (> 95 > 167), and estuarine algae (0.007).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 1.7 ppm and whole fish of 1.2 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm and less than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are also less than the avian subacute LC_{50} value of 136 ppm and less than the avian reproductive NOAEL of 25 ppm. For a single typical use on corn, chlorpyrifos would not seem to be a concern for wildlife feeding on fish and other aquatic organisms.

EFED modeled a second, more erodible site for aquatic EECs using the typical use rate and the PRZM3.12-EXAMS model. The soil was Loring silt loam in Jackson Co., Mississippi with local rainfall conditions. The following table provides the terrestrial and aquatic risk quotients.

Granular Risk Quotients for Corn in Jackson Co., Mississippi
(Pre-Plant, Ground Broadcast; 1 Application at 1.1 lbs ai/A; 4-inch Soil Incorporation)
(Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on PRZM3.12-EXAMS Model)

Species	Toxicity	Exposure	Toxicity Dose	Risk Quotient
Mammalian Acute LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	97 mg/kg	1.7 mg/ft^2*	1.5 mg 3.4 mg 97 mg	1.1 0.50 0.018
Avian Acute Oral LD_{50} (27.7 grams body wt.)	10 mg/kg	1.7 mg/ft^2*	0.28 mg	6.1
Freshwater Fish Acute LC_{50}	1.8 ppb	2.7 ppb		1.5
Fish Reproduction NOAEC	0.57 ppb	1.3 - 2.2 ppb		2.3 - 3.9
Aquatic Invertebrate Acute LC_{50}	0.10 ppb	2.7 ppb		27
Freshwater Invert. Reproduction NOAEC	0.04 ppb	1.3 - 2.2 ppb		32 - 55
Estuarine Fish Acute LC_{50}	0.96 ppb	2.7 ppb		2.8
Estuarine Fish Reproduction NOAEC	0.28 ppb	1.3 - 2.2 ppb		4.6 - 7.9
Estuarine Invertebrate Acute LC_{50}	0.035 ppb	2.7 ppb		77
Estuarine Invert. Reproduction NOAEC	< 0.0046 ppb	1.3 - 2.2 ppb		>280 - >480
Estuarine Algae EC_{50}	140 ppb	2.7 ppb		0.019

$$* \text{ mg ai/foot}^2 = \frac{1.1 \text{ lb ai/A} \times 453{,}590 \text{ mg/lb} \times 15\% \text{ exp.}}{43{,}560 \text{ ft}^2/\text{A}} = 1.7 \text{ mg/ft}^2$$

Risk Summary for a Granular Broadcast Application on Corn in Mississippi: Chlorpyrifos granules broadcast at pre-plant at 1.1 lbs ai/A and soil incorporated to a depth of 4-inches yield risk quotients in Mississippi exceed the levels of concern for non-target aquatic and terrestrial animals. The range of risk quotients for Mississippi are mammalian acute (0.018-1.1), avian acute (6.1), freshwater fish acute (1.5) and reproduction NOAEL (2.3-3.9), aquatic invertebrate acute (27) and reproduction NOAEL (32-55), estuarine fish acute (2.8) and reproduction (4.6-7.9) and estuarine invertebrate acute (77) and reproduction NOAEL (> 280 > 480), and estuarine algae (0.019).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 5.1 ppm and whole fish of 3.5 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm and less than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm and less than the avian reproductive NOAEL of 25 ppm.

Comparison of the risk quotients for applications in Iowa and Mississippi indicate that terrestrial risk quotients are the same. Based on local differences in risks based on different soil types and weather conditions found in Iowa and Mississippi, aquatic risk quotients in Iowa are about 14 percent lower than RQs in Mississippi. The typical use rate on corn at 1.1 lbs ai./A applied as a T-band treatment at-plant yields risk quotients higher than the above RQ values for Iowa (2 fold) and Mississippi (1.7 fold).

Risk Summary for Corn Uses: Application of spray and granular formulations yield risk quotients which indicate high acute risks to small terrestrial mammals, birds and aquatic organisms, except estuarine algae. The high risk quotients are confirmed by mortality and cholinesterase inhibition effects on small mammals and birds in the corn field study. The field study did not monitor for aquatic effects, but measured chlorpyrifos residues in water adjacent to treated fields ranged from non-detect to 115 ppb. The extent of adverse effects on local populations of terrestrial wildlife is difficult to estimate. Many carcasses and some effected wildlife species were found in carcass searches which covered only a small portion of the treated areas. Carcass recovery studies suggest that large numbers of wildlife are not found in search areas. If the percentage of casualties testing positive for chlorpyrifos residues reflect the percentage of all casualties found, approximately 60 percent of the casualties are affected by chlorpyrifos. If the 60 percent, chlorpyrifos-affected wildlife is extrapolated to the total local population and corrected for percent recovery and percent of treated area, covered in carcass searches, the estimate of number of wildlife affected by chlorpyrifos should begin to raise concerns about non-target species. The duration of time (i.e., 56 to 90 days) that EECs for several use patterns on corn exceed the acute LC50 values for fish and/or aquatic invertebrate species should also raise concerns for aquatic species.

(ii) Cover crops (alfalfa, clover and grass grown for seed, mint, and wheat)

Chlorpyrifos applications to cover crops, such as alfalfa, clover for seed, grass for seed, and wheat are largely limited to liquid formulations. The foliar spray rates are 0.5 lbs ai/A (2 treatments) for wheat and 0.25 to 1.0 lb ai/A (once per cutting and up to 4 times per season) aerially sprayed on alfalfa. Ground applications on clover grown for seed are 2.0 lbs ai/A preplant and foliar sprays (limited to Oregon). Ground and aerial applications to grass grown for seed use are sprayed three times at 1 lb ai/A (use limited to CA, ID, OR, SD, and WA). Mint uses include 2 lbs ai/A applications for a pre-plant, soil incorporated treatment (limited to Oregon) and for a foliar, ground broadcast or sprinkler irrigation treatment (1 application each).

Runoff from foliar applications to cover crops is expected to be reduced compared to crops grown on plowed or bare ground. The GENEEC and PRZM3-EXAMS Models estimate EECs for row crops, but data on runoff are unavailable to model EECs for vegetative ground cover. The degree to which ground cover reduces runoff and yields lower EECs is unknown. Hence, the aquatic risk quotients in the following tables for these cover crops are higher than would actually be anticipated.

Alfalfa Uses: Alfalfa is in the top five crops for chlorpyrifos usage. Chlorpyrifos is applied to an average of about 3 percent (likely maximum of 3 percent treated) of the approximately 24,000,000 acres of alfalfa in the U.S. According to BEAD, the typical average chlorpyrifos usage on alfalfa is 1.1 applications at 0.7 lbs ai/A on approximately 670,000 to 840,000 acres. The leading states using chlorpyrifos in decreasing order of poundage are California, Pennsylvania, Missouri, Illinois, Kansas, and Colorado which represent about 55% of the chlorpyrifos used on alfalfa.

Wildlife utilization of alfalfa fields is high including a broad diversity of avian and mammalian species. Alfalfa fields are heavily used by a large number of wildlife in a many states. Ring-necked pheasants, grouses, partridges, quail, sandhill crane, ducks, geese, mourning dove, songbirds, rabbits, groundhogs, muskrats, deer and elk feed in alfalfa fields to a medium to high degree. While it is unlikely that deer and elk might be adversely affected, because of their large size, chlorpyrifos applications to alfalfa could adversely affect many of the other species that consume food items (such as seeds, insects and vegetation in treated fields. Many of the avian species also nest in alfalfa fields.

Risk assessments for alfalfa treatments have been made using maximum application rates as an initial screen for adverse effects and a refinement with typical use rate. Risk quotients have been estimated for a granular at-plant application, limited to Missouri and four post-emergent foliar spray treatments.

Alfalfa granular use: Chlorpyrifos granules are applied to alfalfa at-planting at 1.0 lb ai/A in-furrow and incorporated into the soil. Only one application can be made with granules per season. Four applications of Lorsban 4 EC per year can be made per season. The following table summarizes risks from an alfalfa at-plant granular use.

Granular Risk Quotients for Alfalfa Limited to Missouri (At-plant, In-furrow Treatment, 1 Application at 1.0 lb ai/A; Assume 4-inch Soil Incorporation) (Terrestrial EEC's Based on Formula*; Aquatic EEC's Based on GENEEC Model)				
Species	**Toxicity**	**Exposure**	**Toxicity Dose**	**Risk Quotient**
Mammalian Acute LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	97 mg/kg	1.6 mg/ft^2*	1.5 mg 3.4 mg 97 mg	1.1 0.47 0.016
Avian Acute Oral LD_{50} (27.7 grams body wt.)	10 mg/kg	1.6 mg/ft^2*	0.28 mg	5.7
Freshwater Fish Acute LC_{50}	1.8 ppb	0.83 ppb		3.5
Fish Reproduction NOAEC	0.57 ppb	0.4-0.72 ppb		0.70 - 1.3
Aquatic Invertebrate Acute LC_{50}	0.10 ppb	0.83 ppb		8.3
Freshwater Invert. Reproduction NOAEC	0.04 ppb	0.4-0.72 ppb		10 - 18
Estuarine Fish Acute LC_{50}	0.96 ppb	0.83 ppb		0.86
Estuarine Fish Reproduction NOAEC	0.28 ppb	0.4-0.72 ppb		1.4 - 2.6
Estuarine Invertebrate Acute LC_{50}	0.035 ppb	0.83 ppb		24
Estuarine Invert. Reproduction NOAEC	< 0.0046 ppb	0.4-0.72 ppb		>87 > 160

* mg ai/foot^2 = $\frac{1.0 \text{ lb ai/A X } 453{,}590 \text{ mg/lb X } 15\% \text{ exp.}}{43{,}560 \text{ ft}^2\text{/A}}$ = 1.6 mg/ft^2

Risk Summary for Maximum Alfalfa Pre-plant Uses: Risk quotients for chlorpyrifos uses on alfalfa as pre-plant granular exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.016 to 1.1), avian subacute (1.5-2.6), fish acute (3.5) and reproduction (0.70-1.3), acute aquatic invertebrate (8.3) and reproduction (10-18), estuarine fish acute (0.86) and reproduction (1.4-2.6), and estuarine invertebrate acute (24) and reproduction (> 87 > 160).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 1.6 ppm and whole fish of 1.1 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm and less than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm and less than the avian reproductive NOAEL of 25 ppm.

Alfalfa spray use: Chlorpyrifos may be sprayed on foliar alfalfa four times per season (once per cutting) at 0.25-1 lb ai/A per treatment. The maximum of usage is limited to 4 lbs ai/A per season. Treatments are applied by ground, sprinkler irrigation, or aerial equipment. For terrestrial exposures, it is assumed that the aerial applications are spaced about 6 weeks apart and that residues from previous applications are inconsequential. Aquatic EECs have been calculated using the GENEEC Model. The GENEEC Model assumes runoff levels from field crops with bare ground rather than for cover crops, like alfalfa. Since cover crops reduce erosion and runoff levels, the risk estimates for aquatic organisms may be overestimated. The following table

summarizes risk quotients for 4 aerial, foliar spray applications.

Risk Quotients for Alfalfa
(Postemergent/foliar, Aerial Spray; 4 Applications at 1.0 lbs ai/A; 42-Day Interval)
(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model)

Species	Exposure	Toxicity	Risk Quotient
Mammalian Herbivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	135 - 240 ppm	102 ppm 147 ppm 647 ppm	1.3 - 2.4 0.92 - 1.6 0.21 - 0.37
Mammalian Insectivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	15 - 135 ppm	102 ppm 147 ppm 647 ppm	0.15 - 1.3 0.10 - 0.92 0.023- 0.21
Mammalian Granivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	15 ppm	462 ppm 647 ppm 3233 ppm	0.032 0.023 0.005
Mammalian Subacute Dietary LC_{50}	15 - 240 ppm	1330 ppm	0.011- 0.18
Mammalian Reproduction NOAEL	15 - 240 ppm	10 ppm	1.5 - 24
Avian Subacute Dietary LC_{50}	15 - 240 ppm	136 ppm	0.11 - 1.8
Avian Reproduction NOAEL	15 - 240 ppm	25 ppm	0.6 - 9.6
Freshwater Fish Acute LC_{50}	18 ppb	1.8 ppb	10
Fish Reproduction NOAEC	8.7 - 16 ppb	0.57 ppb	15 - 28
Aquatic Invertebrate Acute LC_{50}	18 ppb	0.10 ppb	180
Freshwater Invert. Reproduction NOAEC	8.7 - 16 ppb	0.04 ppb	220 - 400
Estuarine Fish Acute LC_{50}	18 ppb	0.96 ppb	19
Estuarine Fish Reproduction NOAEC	8.7 - 16 ppb	0.28 ppb	31 - 57
Estuarine Invertebrate Acute LC_{50}	18 ppb	0.035 ppb	510
Estuarine Invert. Reproduction NOAEC	8.7 - 16 ppb	< 0.0046 ppb	>1900 > 3500

Risk Summary for Maximum Alfalfa Post-emergent Use: Risk quotients for 4 foliar spray applications exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are mammalian acute (0.005 to 2.4), subacute (0.011-0.18) and reproduction (1.5-24), avian subacute (0.11-2.6) and reproduction (0.6-9.6), fish acute (10) and reproduction (15-28), acute aquatic invertebrate (180) and reproduction (220-400), estuarine fish acute (19) and reproduction (31-57), and estuarine invertebrate acute (510) and reproduction (> 1900 > 3500).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 34 ppm and whole fish of 24 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm but more than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm but more than the avian reproductive NOAEL of 25 ppm.

Typical Alfalfa Use: According to BEAD, the typical use rate on alfalfa is 1.1 post-emergent, foliar spray applications at an average of 0.7 lbs ai/A on approximately 670,000 to 835,000 acres. Risk quotients for a typical, foliar spray application on alfalfa are estimated in the following table.

Risk Quotients for Typical Use on Alfalfa
(Post-emergent, Foliar Spray; 1 Application at 0.7 lbs ai/A)
(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model)

Surrogate Species	Exposure	Toxicity	Risk Quotient
Mammalian Herbivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	10.5 - 168 ppm	102 ppm 147 ppm 647 ppm	0.10 - 1.6 0.071 - 1.1 0.016 - 0.26
Mammalian Insectivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	10.5 - 95 ppm	102 ppm 147 ppm 647 ppm	0.10 - 0.93 0.071 - 0.65 0.016 - 0.15
Mammalian Granivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	10.5 ppm	462 ppm 647 ppm 3233 ppm	0.023 0.016 0.003
Mammalian Subacute Dietary LC_{50}	10.5 - 168 ppm	1330 ppm	0.008 - 0.13
Mammalian Reproduction NOAEL	10.5 - 168 ppm	10 ppm	1.1 - 17
Avian Subacute Dietary LC_{50}	10.5 - 168 ppm	136 ppm	0.077 - 1.2
Avian Reproduction NOAEL	10.5 - 168 ppm	25 ppm	0.42 - 6.7
Freshwater Fish Acute LC_{50}	3.56 ppb	1.8 ppb	2.0
Fish Reproduction NOAEC	1.7 - 3.14 ppb	0.57 ppb	3.0 - 5.5
Aquatic Invertebrate Acute LC_{50}	3.56 ppb	0.10 ppb	36
Freshwater Invert. Reproduction NOAEC	1.7 - 3.14 ppb	0.04 ppb	52 - 78
Estuarine Fish Acute LC_{50}	3.56 ppb	0.96 ppb	3.7
Estuarine Fish Reproduction NOAEC	1.7 - 3.14 ppb	0.28 ppb	6.1 - 11
Estuarine Invertebrate Acute LC_{50}	3.56 ppb	0.035 ppb	100
Estuarine Invert. Reproduction NOAEC	1.7 - 3.14 ppb	< 0.0046 ppb	> 370 > 680

Risk Summary for a Typical Aerial, Alfalfa Use: Risk quotients derived for a single foliar application at the typical use rate on alfalfa exceed the levels of concern for most non-target aquatic and terrestrial animals. The range of RQs for an average application rate is as follows: mammalian acute (0.003-1.6) and reproduction (1.1-17), avian acute (0.08-1.2) and reproduction (0.42-6.7), freshwater fish acute (2.0) and reproduction (3.0-5.5), freshwater invertebrates acute (36) and reproduction (52-78), estuarine fish acute (3.7) and reproduction (6.1-11), and estuarine invertebrates acute (100) and reproduction (> 370 > 680). About 10 percent of the alfalfa crop is treated a second time which may increase the above risk quotients depending on the time interval between treatments.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 6.6 ppm and whole fish of 4.6 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm and less than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm and less than the avian reproductive NOAEL of 25 ppm.

Dow has indicated that the typical chlorpyrifos use on alfalfa is a foliar aerial application at 1.5 pt of Lorsban 4E per acre (0.75 lbs ai./A). Dow's typical use rate on alfalfa is slightly higher than the 0.7 lbs ai./A cited by BEAD (1999). If Dow's typical use rate is correct the risks are about 7 percent higher than estimated above.

Clover Grown for Seed Use: Clover acreage treated with chlorpyrifos, the total amount used on clover, and typical use rates have not been identified. Chlorpyrifos is sprayed by ground equipment on clover grown for seed before planting and at the foliar stage, once each at rates of 2 lbs ai/A. The interval between treatments is assumed to be 14 days. The integrated terrestrial EECs for the two applications are estimated with the FATE model for accumulated residues. Aquatic EECs are estimated using the GENEEC model, which is likely to overestimate runoff and risks for this cover crop. Risks to fish and wildlife are assessed for clover grown for seed in the table below.

Risk Quotients for Clover Grown for Seed
(Preplant and foliar, Ground Spray; 1 Application each at 2.0 lbs ai/A; Interval Unknown, Assumed 14 Days)
(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on GENEEC Model)

Species	Exposure	Toxicity	Risk Quotient
Mammalian Herbivores LD_{50} (15 grams)	338 - 600 ppm	102 ppm	3.3 - 5.9
(35 grams)		147 ppm	2.3 - 4.1
(1000 grams)		647 ppm	0.52 - 0.93
Mammalian Insectivores LD_{50} (15 grams)	38 - 338 ppm	102 ppm	0.37 - 5.9
(35 grams)		147 ppm	0.26 - 4.1
(1000 grams)		647 ppm	0.059- 0.52
Mammalian Granivores LD_{50} (15 grams)	38 - 338 ppm	462 ppm	0.082- 0.73
(35 grams)		647 ppm	0.059- 0.52
(1000 grams)		3233 ppm	0.012- 0.10
Mammalian Subacute Dietary LC_{50}	338 - 600 ppm	1330 ppm	0.25 - 0.45
Mammalian Reproduction NOAEL	338 - 600 ppm	10 ppm	34 - 60
Avian Subacute Dietary LC_{50}	338 - 600 ppm	136 ppm	2.5 - 4.4
Avian Reproduction NOAEL	338 - 600 ppm	25 ppm	14 - 24
Freshwater Fish Acute LC_{50}	15 ppb	1.8 ppb	8.3
Fish Reproduction NOAEC	7.25- 13 ppb	0.57 ppb	13 - 23
Aquatic Invertebrate Acute LC_{50}	15 ppb	0.10 ppb	150
Freshwater Invert. Reproduction NOAEC	7.25- 13 ppb	0.04 ppb	180 - 320
Estuarine Fish Acute LC_{50}	15 ppb	0.96 ppb	16

Estuarine Fish Reproduction NOAEC	7.25- 13 ppb	0.28 ppb	26 - 46
Estuarine Invertebrate Acute LC_{50}	15 ppb	0.035 ppb	430
Estuarine Invert. Reproduction NOAEC	7.25- 13 ppb	< 0.0046 ppb	>1600 > 2800

Risk Summary for Maximum Clover Uses: Risk quotients for chlorpyrifos sprayed to clover as pre-plant and foliar applications at 2 lbs ai/A each exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are acute LD_{50}s for small mammals (0.012 to 5.9), acute LC_{50}s for birds (2.5-4.4), acute fish LC_{50}s (8.3-16) and aquatic invertebrate acute LC_{50}s (150-430), and chronic NOAECs for small mammals (34-60), bird NOAECs (14-24), fish NOAECs (13-23), aquatic invertebrate NOAECs (>180 > 2800). The acute LC_{50} values for both fish and aquatic invertebrate species are exceeded by EECs for more than 56 days following two applications on alfalfa.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 28 ppm and whole fish of 20 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm but more than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm but more than the avian reproductive NOAEL of 25 ppm.

Grass Grown for Seed Use: Less than 1 percent of the total chlorpyrifos poundage used on agricultural crops is used for grass grown for seed. Acreage treated with chlorpyrifos and typical use rates have not been identified for grass growth for seed. Chlorpyrifos is aerially sprayed on grass three times per season at 1 lb ai/A each. Since the labels do not specify the minimal interval between treatments, it is assumed to be 7 days (the default value). Accumulation of terrestrial residues were estimated with the FATE Model. The GENEEC model is likely to overestimate EECs and aquatic risks for this cover crop, because the model assumes runoff from bare ground. Grass would be expected to reduce runoff. Risks to fish and wildlife are assessed for grass grown for seed in the table below.

Risk Quotients for Grass Grown for Seed
(Foliar, Aerial Spray; 3 Application each at 1.0 lb ai/A; Interval Unknown, Assumed 7 Days)
(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on GENEEC Model)

Species	Exposure	Toxicity	Risk Quotient
Mammalian Herbivores LD_{50} (15 grams body wt.)	236 - 420 ppm	102 ppm	2.3 - 4.1
(35 grams body wt.)		147 ppm	1.6 - 2.9
(1000 grams body wt.)		647 ppm	0.36 - 0.65
Mammalian Insectivores LD_{50} (15 grams body wt.)	26 - 236 ppm	102 ppm	0.25 - 2.3
(35 grams body wt.)		147 ppm	0.18 - 1.6
(1000 grams body wt.)		647 ppm	0.040- 0.36
Mammalian Granivores LD_{50} (15 grams body wt.)	26 - 236 ppm	462 ppm	0.056- 0.91
(35 grams body wt.)		647 ppm	0.040- 0.65
(1000 grams body wt.)		3233 ppm	0.008- 0.13
Mammalian Subacute Dietary LC_{50}	236 - 420 ppm	1330 ppm	0.18 - 0.32

Mammalian Reproduction NOAEL	236 - 420 ppm	10 ppm	24 - 42
Avian Subacute Dietary LC_{50}	236 - 420 ppm	136 ppm	1.7 - 3.1
Avian Reproduction NOAEL	236 - 420 ppm	25 ppm	9.4 - 17
Freshwater Fish Acute LC_{50}	17 ppb	1.8 ppb	9.4
Fish Reproduction NOAEC	8.0 - 15 ppb	0.57 ppb	14 - 26
Aquatic Invertebrate Acute LC_{50}	17 ppb	0.10 ppb	170
Freshwater Invert. Reproduction NOAEC	8.0 - 15 ppb	0.04 ppb	200 - 380
Estuarine Fish Acute LC_{50}	17 ppb	0.96 ppb	18
Estuarine Fish Reproduction NOAEC	8.0 - 15 ppb	0.28 ppb	29 - 54
Estuarine Invertebrate Acute LC_{50}	17 ppb	0.035 ppb	490
Estuarine Invert. Reproduction NOAEC	8.0 - 15 ppb	< 0.0046 ppb	>1700 > 3300

Risk Summary for Maximum Grass grown for Seed: Risk quotients for chlorpyrifos aerially applied to grass grown for seed exceed the levels of concern for most non-target aquatic and terrestrial animals. The range of risk quotients are mammalian acute (0.008-4.1), subacute (0.18-0.32), and reproduction (24-42), avian subacute (1.7-3.1) and chronic (9.4-17), fish acute (9.4-18) and chronic (14-54), aquatic invertebrate acute (170-490) and chronic (> 200 > 3300).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 31 ppm and whole fish of 22 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm but more than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm but more than the avian reproductive NOAEL of 25 ppm.

Mint Uses: Chlorpyrifos is sprayed by ground equipment before planting (soil incorporated) and at the foliar stage, once each at rates of 2 lbs ai/A. Risks to fish and wildlife from one foliar application at 2 lbs ai/A are summarized in the table below. Typical use rates have not been identified.

Risk Quotients for Mint
(Foliar, Ground Spray; 1 Application at 2.0 lbs ai/A)
(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on GENEEC Model)

Species	Exposure	Toxicity	Risk Quotient
Mammalian Herbivores LD_{50} (15 grams) (35 grams) (1000 grams)	270 - 480 ppm	102 ppm 147 ppm 647 ppm	2.6 - 4.7 1.8 - 3.3 0.42 - 0.74
Mammalian Insectivores LD_{50} (15 grams) (35 grams) (1000 grams)	30 - 270 ppm	102 ppm 147 ppm 647 ppm	0.29 - 2.6 0.20 - 1.8 0.046- 0.42

Mammalian Granivores LD_{50} (15 grams) (35 grams) (1000 grams)	30 - 270 ppm	462 ppm 647 ppm 3233 ppm	0.065- 0.58 0.046- 0.42 0.009- 0.084
Mammalian Subacute Dietary LC_{50}	30 - 480 ppm	1330 ppm	0.023- 0.36
Mammalian Reproduction NOAEL	30 - 480 ppm	10 ppm	3.0 - 48
Avian Subacute Dietary LC_{50}	30 - 480 ppm	136 ppm	0.22- 3.5
Avian Reproduction NOAEL	30 - 480 ppm	25 ppm	1.2 - 19
Freshwater Fish Acute LC_{50}	7.4 ppb	1.8 ppb	4.1
Fish Reproduction NOAEC	3.72- 6.46 ppb	0.57 ppb	6.5 - 11
Aquatic Invertebrate Acute LC_{50}	7.4 ppb	0.10 ppb	74
Freshwater Invert. Reproduction NOAEC	3.72- 6.46 ppb	0.04 ppb	93 - 160
Estuarine Fish Acute LC_{50}	7.4 ppb	0.96 ppb	7.7
Estuarine Fish Reproduction NOAEC	3.72- 6.46 ppb	0.28 ppb	13 - 23
Estuarine Invertebrate Acute LC_{50}	7.4 ppb	0.035 ppb	210
Estuarine Invert. Reproduction NOAEC	3.72- 6.46 ppb	< 0.0046 ppb	> 810 > 1400

Risk Summary for Maximum Mint Uses: Risk quotients for chlorpyrifos sprayed on mint as a foliar application at 2 lbs ai/A exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients are acute LD_{50}s for small mammals (0.009 to 4.7), acute LC_{50}s for birds (0.22-3.5), acute fish LC_{50}s (4.1-7.7) and aquatic invertebrate acute LC_{50}s (74-210), and chronic NOAECs for small mammals (3.0-48), bird NOAECs (1.2-19), fish NOAECs (13-160), aquatic invertebrate NOAECs (93 > 1400).

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 15 ppm and whole fish of 10 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm but more than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm and less than the avian reproductive NOAEL of 25 ppm.

Wheat Uses: Chlorpyrifos is currently applied to only about 1 percent (likely maximum of 1 percent treated) of the approximately 43,000,000 acres of winter wheat fields in the U.S. The leading states using chlorpyrifos on wheat in decreasing order are Texas, Colorado, Kansas, Wyoming, Montana, and New Mexico.

Wildlife utilization of wheat fields is relatively high compared to many other crops. Wildlife which feed in wheat fields include quail, pheasant, grouse, partridge, prairie chicken, wild turkey, pigeons, doves, songbirds, cranes, ducks, geese, rabbit, deer, and antelope to a low to high degree. While it is unlikely that deer or antelope might be adversely affected, because of their large size, many of the other species could be affected by consumption of food items (such as seeds, insects and vegetation) found in chlorpyrifos-treated wheat fields. Bobwhite quail,

pheasant, wild turkeys, songbirds, ducks, cranes, and rabbits also nest and brood young in wheat fields. Wheat fields have been identified as important feeding areas for migratory species in the flyways.

Maximum Wheat Use: Chlorpyrifos use on winter wheat can be sprayed twice per season at 0.5 lb ai/A with ground, sprinkler, or aerial equipment. The interval between applications is assumed to be 7 days. Risks to fish and wildlife are assessed for wheat uses in the table below.

Risk Quotients for Wheat
(Foliar, Aerial Spray; 2 Applications at 0.5 lbs ai/A; 7-Day Interval)
(Terrestrial EEC's Based on FATE Model; Aquatic EEC's Based on GENEEC Model)

Species	Exposure	Toxicity	Risk Quotient
Mammalian Herbivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	102 - 180 ppm	102 ppm 147 ppm 647 ppm	1.0 - 1.8 0.69 - 1.2 0.16 - 0.28
Mammalian Insectivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	13 - 102 ppm	102 ppm 147 ppm 647 ppm	0.13 - 1.0 0.088- 0.69 0.020- 0.16
Mammalian Granivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	13 - 102 ppm	462 ppm 647 ppm 3233 ppm	0.028- 0.22 0.020- 0.16 0.004- 0.032
Mammalian Subacute Dietary LC_{50}	13 - 180 ppm	1330 ppm	0.010- 0.14
Mammalian Reproduction NOAEL	13 - 180 ppm	10 ppm	1.3 - 18
Avian Subacute Dietary LC_{50}	13 - 180 ppm	136 ppm	0.096- 1.3
Avian Reproduction NOAEL	13 - 180 ppm	25 ppm	0.52 - 7.2
Freshwater Fish Acute LC_{50}	5.5 ppb	1.8 ppb	3.1
Fish Reproduction NOAEC	2.6 - 4.9 ppb	0.57 ppb	4.6 - 8.6
Aquatic Invertebrate Acute LC_{50}	5.5 ppb	0.10 ppb	55
Freshwater Invert. Reproduction NOAEC	2.6 - 4.9 ppb	0.04 ppb	65 - 120
Estuarine Fish Acute LC_{50}	5.5 ppb	0.96 ppb	5.7
Estuarine Fish Reproduction NOAEC	2.6 - 4.9 ppb	0.28 ppb	9.3 - 18
Estuarine Invertebrate Acute LC_{50}	5.5 ppb	0.035 ppb	160
Estuarine Invert. Reproduction NOAEC	2.6 - 4.9 ppb	< 0.0046 ppb	> 570 > 1100

Risk Summary for Maximum Aerial, Wheat Use: Risk quotients for chlorpyrifos use on wheat as a foliar spray application exceed the levels of concern for most non-target aquatic and terrestrial animals. Risk quotients for small mammals are (acute 0.005-1.8), subacute (0.01-0.14) and reproduction (1.3-18), avian subacute (0.096-1.3) and reproduction (0.52-7.2), fish acute (3.1) and reproduction (4.6-8.6), and aquatic invertebrate acute (55) and reproduction (65-120). Estuarine risk quotients for the few areas where wheat is grown near coastal areas are estuarine fish acute (5.7) and reproduction (9.3-18) and estuarine invertebrate acute (160) and reproduction

(> 570 > 1100). Buffer zones are required for ground and aerial applications on wheat. The degree to which the buffer zone reduces aquatic risks is unknown. When data from the Spray Drift Task Force are finalized, the aquatic risks can be refined.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 10 ppm and whole fish of 7.1 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm and equal the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm and less than the avian reproductive NOAEL of 25 ppm.

Typical Wheat Use: According to BEAD, the typical average chlorpyrifos usage on spring wheat is 1 application of 0.39 lbs ai/A and on winter wheat is 1.2 foliar applications at 0.47 lbs ai/A. The risk quotients are assessed for a single typical application scenario on winter wheat in the table below.

Risk Quotients for Typical Use on Winter Wheat
(Post-emergent, Aerial Foliar Spray; 1 Application at 0.47 lbs ai/A)
(Terrestrial EEC's Based on Nomograph; Aquatic EEC's Based on GENEEC Model)

Surrogate Species	Exposure	Toxicity	Risk Quotient
Mammalian Herbivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	63 - 113 ppm	102 ppm 147 ppm 647 ppm	0.62 - 1.1 0.43 - 0.77 0.097 - 0.17
Mammalian Insectivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	7 - 63 ppm	102 ppm 147 ppm 647 ppm	0.069 - 0.62 0.048 - 0.43 0.011 - 0.097
Mammalian Granivores LD_{50} (15 grams body wt.) (35 grams body wt.) (1000 grams body wt.)	7 ppm	462 ppm 647 ppm 3233 ppm	0.015 0.011 0.002
Mammalian Subacute Dietary LC_{50}	7 - 113 ppm	1330 ppm	0.005 - 0.085
Mammalian Reproduction NOAEL	7 - 113 ppm	10 ppm	0.70 - 11
Avian Subacute Dietary LC_{50}	7 - 113 ppm	136 ppm	0.051 - 0.83
Avian Reproduction NOAEL	7 - 113 ppm	25 ppm	0.28 - 4.5
Freshwater Fish Acute LC_{50}	2.4 ppb	1.8 ppb	1.3
Fish Reproduction NOAEC	1.13 - 2.12 ppb	0.57 ppb	2.0 - 3.7
Aquatic Invertebrate Acute LC_{50}	2.4 ppb	0.10 ppb	24
Freshwater Invert. Reproduction NOAEC	1.13 - 2.12 ppb	0.04 ppb	28 - 53
Estuarine Fish Acute LC_{50}	2.4 ppb	0.96 ppb	2.5
Estuarine Fish Reproduction NOAEC	1.13 - 2.12 ppb	0.28 ppb	4.0 - 7.6
Estuarine Invertebrate Acute LC_{50}	2.4 ppb	0.035 ppb	69

Estuarine Invert. Reproduction NOAEC	1.13 - 2.12 ppb	< 0.0046 ppb	> 240 > 460

Risk Summary for a Typical Aerial, Wheat Use: Risk quotients derived for a single application at the typical use rate on wheat exceed the levels of concern of most non-target aquatic and terrestrial animals. The range of RQs for an average application rate is as follows: mammalian acute (0.002-1.1) and reproduction (0.70-11), avian acute (0.051-0.83) and reproduction (0.28-4.5), freshwater fish acute (1.3) and reproduction (2.0-3.7), freshwater invertebrates acute (24) and reproduction (28-53), estuarine fish acute (2.5) and reproduction (4.0-7.6), and estuarine invertebrates acute (69) and reproduction (> 240 > 460). The acute LC_{50} value for aquatic invertebrate species is exceeded by the EECs for about 56 days. When data from the Spray Drift Task Force are finalized, the aquatic risks can be refined.

Food Chain Effects: Piscivorous mammals are exposed to estimated residues in the fish viscera of 4.4 ppm and whole fish of 3.1 ppm. These levels are less than the mammalian subacute LC_{50} value of 1330 ppm and less than the mammalian reproductive NOAEL of 10 ppm. These residue levels in fish are less than the avian subacute LC_{50} value of 136 ppm and less than the avian reproductive NOAEL of 25 ppm.